Fish Populations of the Wild & Scenic Missouri River, Montana

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PREFACE

The Missouri River from Fort Benton to Fred Robinson Bridge (US Highway 191) was designated a component of the National Wild and Scenic River System in October 1976. This 240-kilometer (149-mile) segment is the only major portion of the Missouri River to be protected and preserved in its natural, free-flowing state.

Today, floaters enjoy scenic vistas which remain much as first described by Lewis and Clark in 1805-1806. The Missouri River was the major waterway route to the Rocky Mountain west from the time of Lewis and Clark until the coming of the railroads in the late 1800's.

The Blackfeet, Assiniboine, and Cree held dominion over the river area for many years. At the riverside trading posts of Fort Lewis, Benton, McKenzie, and Piegan, fur trade flourished for a brief period. Steamboats plied the shallow waters as far as Fort Benton, bringing gold seekers and materials for an expanding economy. The exceptionally scenic White Rocks area along the river contains landmarks that recall those days of long ago. LaBarge Rock, Hole-in-the-Wall, Dark Butte, Citadel Rock - the names ring with the excitement and romance of this period of westward expansion.

Later, homesteaders found the Missouri River valley too harsh an environment to pursue their livelihood. The frame and log dwellings they left behind are present-day reminders of dreams that were not to be.

The river's free-flowing nature, protected by its designation to the National Wild and Scenic System, has preserved not only scenery, solitude, and recreational opportunities, but it has also preserved a precious and rare ecological community. A study of a portion of this community is described in the pages of this report.

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ABSTRACT

A fishery inventory and planning study was conducted on a 333-kilometer (km) reach of the mainstem of the middle Missouri River between Morony Dam and Fort Peck Reservoir and on the lower reaches of its principal tributaries, the Marias, Teton, and Judith rivers. The study was made during a five-year period from October 1, 1975, through September 30, 1980. Physical, chemical, and biological characteristics of the waters of importance, or potential importance, to the recreational fishery of the study area were determined.

A total of 92,568 fish were sampled in the mainstem and 8,720 in tributaries. Longitudinal distribution, relative abundance, and size composition of the fish populations were determined. A total of 53 species representing 14 families of fish occur in the study area. Sauger, walleye, channel catfish, shovelnose sturgeon, paddlefish, northern pike, and burbot were the most common game fish species collected. Common nongame species included goldeye, carp, freshwater drum, stonecat, mottled sculpin, and a variety of suckers and minnows. Movements of several important fish species were evaluated by electrofishing catch rate and tag return data. Age and growth studies of eight important fish species indicated growth in the middle Missouri River generally equals or exceeds growth in other waters.

Seasonal spawning migrations of shovelnose sturgeon, sauger, bigmouth and smallmouth buffalo, and blue suckers in the Missouri River and from the Missouri River into major tributaries were identified and monitored. The annual spawning migration of paddlefish from Fort Peck Reservoir into the Missouri River was studied, and nine critical spawning sites were identified. Significant movements of paddlefish to the spawning sites did not occur until flow in the Missouri River at the Virgelle gage station exceeded 396 meters^3/second (m^3/sec) [14,000 feet^3/sec (cfs)].

Aquatic macroinvertebrates, larval fish, and forage fish were studied in the Missouri River and in the lower reaches of major tributaries. Water temperature was monitored at four sites on the Missouri River and at one site on the lower Marias River. Water chemistry was studied at six stations on the Missouri River. In 1977, a paddlefish creel census was conducted in a 23-km segment of the Missouri River between Robinson Bridge and Fort Peck Reservoir. An estimated 1,625 anglers fished 2,526 man-days and harvested 666 paddlefish weighing 15.96 metric tons. A partial creel survey of the Missouri River from Morony Dam to Fort Peck Reservoir revealed an excellent sport fishery exists for sauger, shovelnose sturgeon, channel catfish, and several other species. Returns of tagged fish by anglers indicated relatively light harvest rates for most species.

Assessment of human-related activities affecting the aquatic resource indicates water quality degradation and stream dewatering are problems in portions of the study area. Increased exploitation of fossil fuels and nonfuel mineral resources could lead to future environmental problems. Potential dams on the Missouri River near Fort Benton represent the greatest single threat to the aquatic resources of the study area.

INTRODUCTION

A basic inventory is essential in formulating management plans for maintaining and utilizing a fishery. Seldom is this information complete for an entire area or drainage. The middle Missouri River in Montana supports a significant fishery, and prior to this study, basic data on the aquatic resources of this area were lacking.

The aquatic resources of Montana are threatened by an expanding population. Human activities encroach on the aquatic habitat at an alarming rate. These activities on the floodplain, streambanks, and headwaters have altered many streams beyond the point where they can naturally adjust.

Because of the increasing human demand for Montana's limited water supplies for industrial, agricultural, and domestic uses, development of the middle Missouri River appears likely. Projects which remove or impound substantial amounts of stream flow may alter the existing flow regimes and associated aquatic communities. For these reasons the Montana Department of Fish, Wildlife and Parks (DFWP) initiated this study on October 1, 1975. Without basic inventory data on the aquatic resources of the middle Missouri River, little could be done to evaluate conflicting resource demands and minimize adverse impacts on the resource.

A 333-km (207-mile) reach of the mainstem of the middle Missouri River was included in the fisheries inventory. This reach extends from Morony Dam near Great Falls to the headwaters of Fort Peck Reservoir near Landusky. Eleven study sections were established in the reach (Figure 1). In addition, the lower reaches of the Marias, Teton, and Judith rivers were studied. The Marias River entering from the north (including its tributary, the Teton River) and the Judith River from the south are the principal tributaries to the Missouri River in the study area.

The Missouri is the nation's longest river. The 333-km reach covered by this study represents the last major free-flowing portion of the 3,982-km river. From Three Forks to Great Falls, the Missouri is characterized by several dams and intensive bottomland cultivation. From Fort Peck to its junction with the Mississippi River, the Missouri has been substantially altered with channel pilings, flood walls, dams, and reservoirs, all of which have impaired the river's natural values.

The land contiguous to the Missouri River in the study area has retained most of its primitive characteristics. It consists primarily of rolling plains, interrupted by isolated areas of mountain uplift (Missouri River Joint Study 1963). The gorge-like river valley, which lies 150 to 300 meters (m) below the average elevation of the adjacent upland plains, is comprised largely of spectacular, varied, and highly scenic badlands and breaks, ranging from 3 to 16 km in width.

Because of its extraordinary historical, recreational, scenic, and natural values, a 240-km segment of the Missouri River in the study area from Fort Benton to Robinson Bridge has been designated as part of the National Wild and Scenic Rivers System (US Congress 1975a). This inclusion, signed into law on October 13, 1976, affords considerable protection for the last major free-flowing portion of the Missouri River. Under provisions

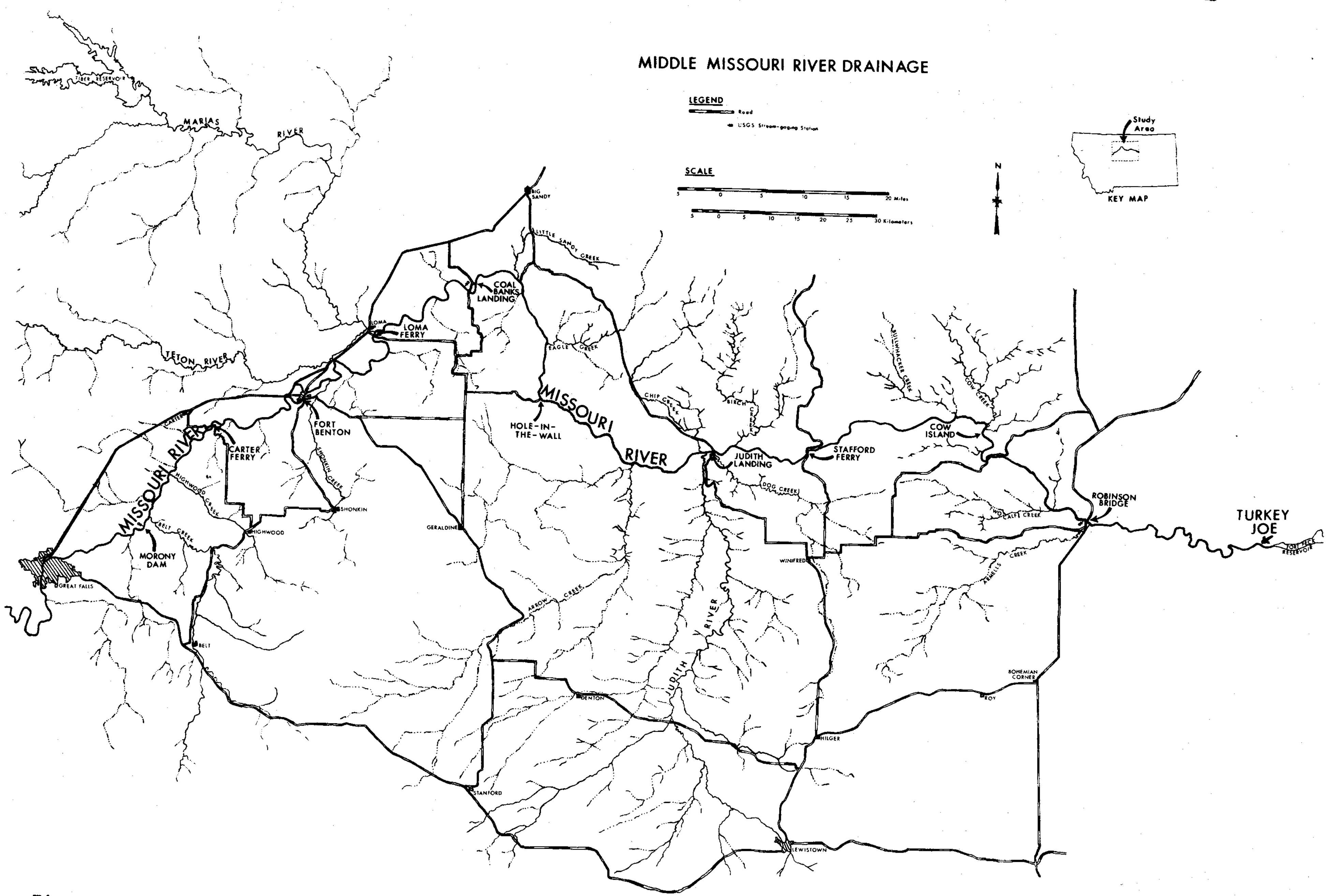


Figure 1. Map of the middle Missouri River drainage showing locations of eleven study sections established on the mainstem of the river (study sections are marked with arrows).

of the legislation, no dams may be built on any of the protected waters and specific protective regulations will be imposed on any new commercial development in designated areas surrounding the protected waters (US Congress 1975b). The law does allow minor diversion and pumping of water from the protected area for agricultural uses. Private landowners in the area can continue with traditional grazing, farming, recreational, and residential uses.

OBJECTIVES

The long-range objective of the study was to follow the inventory procedures developed on the Smith River (Wipperman 1973) and the upper Yellowstone and Shields rivers(Berg 1975) and use the resulting data to prepare recommendations for aquatic resource management on the middle Missouri River. Specific objectives were:

1. To conduct baseline surveys of resident fish populations in 11 study sections on the mainstem of the middle Missouri River,

2. To identify and monitor spawning migrations of paddlefish, shovelnose sturgeon, and sauger in the Missouri River and the lower reaches of the Marias, Judith, and Teton rivers,

3. To tag key fish species with individually numbered tags to determine angler harvest and monitor movement patterns,

4. To determine age and growth of paddlefish, shovelnose sturgeon, sauger, channel catfish, blue sucker, bigmouth and smallmouth buffalo, and freshwater drum in the middle Missouri River,

5. To determine location, seasonality, and success of spawning of important fish species in the middle Missouri River by sampling for larval fish at eight stations on the mainstem of the river and at one station near the mouth of the Marias River,

6. To inventory the aquatic macroinvertebrate community at five stations on the mainstem of the middle Missouri River and at one station each near the mouths of the Marias and Judith rivers,

7. To maintain thermograph stations on the Missouri and Marias rivers to monitor water temperatures,

8. To monitor water chemistry (quality) parameters at six stations on the mainstem of the middle Missouri River,

9. To conduct a partial creel survey on the sport fishery of the middle Missouri River between Morony Dam and Fort Peck Reservoir,

10. To conduct a creel census on the paddlefish fishery between Robinson Bridge and Fort Peck Reservoir, and

11. To identify immediate and future problems affecting the aquatic resources in the study area and recommend solutions to alleviate these problems.

All objectives stated above were accomplished. Findings are presented in the appropriate sections of this completion report.

TECHNIQUES

Water Temperature

Thirty-day continuous recording thermographs were used to monitor water temperature regimes. The recorder box was positioned on the streambank as far above the high water mark as possible. A thermocouple lead, varying in length from 8 to 23 m, was extended into the water through flexible, plastic sewer pipe.

Water Quality

A limited amount of water chemistry (quality) monitoring was conducted during this study. Samples were collected by the DFWP, and laboratory analyses were made by the Water Quality Bureau of the Montana Department of Health and Environmental Sciences. Standard Methods for the Examination of Water and Wastewater were followed (APHA 1975).

Macroinvertebrates

Aquatic macroinvertebrate samples were taken using a rectangular framed 20 x 45 centimeters (cm), conical net kick sampler with fine mesh (300 micron) pores (Figure 2). The net was positioned on the streambed so the current flowed into it. Macroinvertebrates were washed into the net by an operator standing in front of the net kicking into the substrate. A variety of habitat types (cobble, gravel, sand, mud, submerged vegetation, etc.) were sampled at each station to obtain a representative sample. Samples were transferred to jars containing an identifying label and preserved with 10 percent formaldehyde.

In the laboratory, the samples were washed on a US Series No. 30 screen. Material retained by the screen was transferred to an enamel sorting pan where the aquatic macroinvertebrates were separated from vegetation and bottom materials. Separation of macroinvertebrates was accomplished by picking each sample twice. Macroinvertebrates were identified to the lowest taxon practical using keys by Ward and Whipple (1959), Pennak (1953), Brown (1972), and Roemhild (1976). All macroinvertebrate identifications, except chironomids, were verified by Dr. George Roemhild, Montana State University. Chironomids were identified by Dick Oswald, Montana State University.

Larval Fish

Larval fish were sampled with a 0.5 m diameter by 1.6 m long Nitex plankton net (0.75 millimeter (mm) mesh) fitted with a threaded ring sewn at the distal end to accommodate a wide mouth, pint mason jar as the collecting bucket (Figure 3). The net was fished in a stationary position immediately below the surface of the water in main channel border areas of the river. The net was anchored in position in the current by a 4 m length of rope. The volume of water filtered was measured with a Price type-AA current meter positioned at the center of the net orifice. The net was fished for a measured period of time, usually 30 to 60 minutes.

Figure 2. Macroinvertebrate samples were collected with a rectangular framed kick net positioned on the stream bottom.

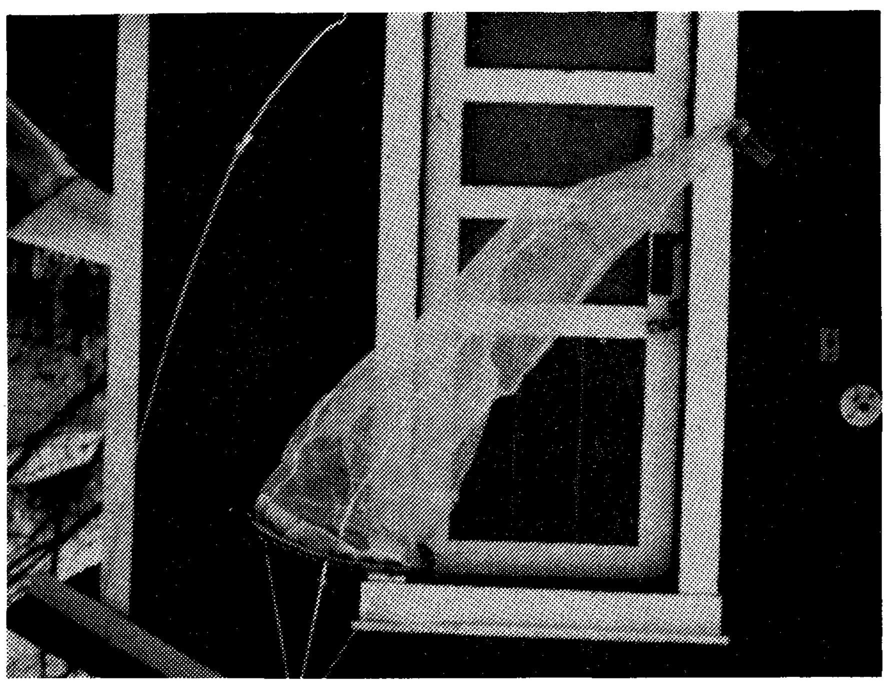


Figure 3. A 0.5 m diameter larval fish net was used to collect drifting fish larvae.

On some occasions the net was fished for less than 30 minutes because of excessive amounts of debris collecting in the nets. The samples were usually collected during the dusk-to-dawn hours of the day at two week intervals.

After the net was retrieved from the river, its contents were thoroughly washed into the collecting jar. All samples were preserved in a 10 percent solution of formaldehyde colored with phloxine-B dye. In the laboratory, the samples were washed on a US Series No. 30 screen. Material retained by the screen was transferred to an enamel sorting pan where the larval fish were extracted. The ploxine-B dye was a deep pink coloring agent which penetrated the fish larvae and aided in separating them from aquatic vegetation and debris. Larvae were identified to the lowest taxon practical using keys by Hogue et al. (1976) and May and Gasaway (1967). For purposes of this study, larval fish were defined as those fish exhibiting undeveloped pectoral, anal, and dorsal fin rays, essentially as suggested by May and Gasaway (1967).

Adult Fish

The middle Missouri River is a substantially larger stream than the Smith or upper Yellowstone River drainages where the previous inventory and planning investigations were conducted. The Missouri has a greater diversity of aquatic habitat types and a larger variety of fish species than the aforementioned drainages. Natural turbidity, deep water, and deceptive current velocities present problems for survey operations in many areas.

Because of these problems, many of the fish population sampling procedures developed during the previous inventory and planning studies could not be used on the Missouri River. A basic objective of this study was to become familiar with proven sampling methods on large rivers and develop sampling equipment and techniques adaptable to the Missouri River. The following fishery sampling gear and methods were tested and used during the study.

Boom-Suspended Electrofishing Apparatus

Alternating or direct current shockers with electrodes suspended from fixed booms have been relatively successful for sampling fish populations in large rivers such as the lower Yellowstone River in Montana (Peterman and Haddix 1975), the Missouri River in Nebraska (Morris 1965, Stuckey 1973), the Missouri River in Missouri (Robinson 1973 and 1977), and other large rivers (FAO 1975).

A boom shocker was constructed for use on the middle Missouri River. Basic design of the boom shocker was adapted largely from boom shockers used in Wisconsin (Novotny and Priegel 1974) with specific modifications similar to those used on the lower Yellowstone River in Montana (Peterman 1978).

The electrofishing apparatus was mounted on a 6.7 m (22 ft.) semi-vee aluminum boat powered by a 245 horsepower (hp) inboard jet (Figure 4). An aluminum boat offers the advantage of simple, reliable grounding of all electrical equipment by the physical attachment of the equipment to the boat (Novotny and Priegel 1974). A metal railing was constructed around the front deck of the boat for safety and to facilitate collection of stunned

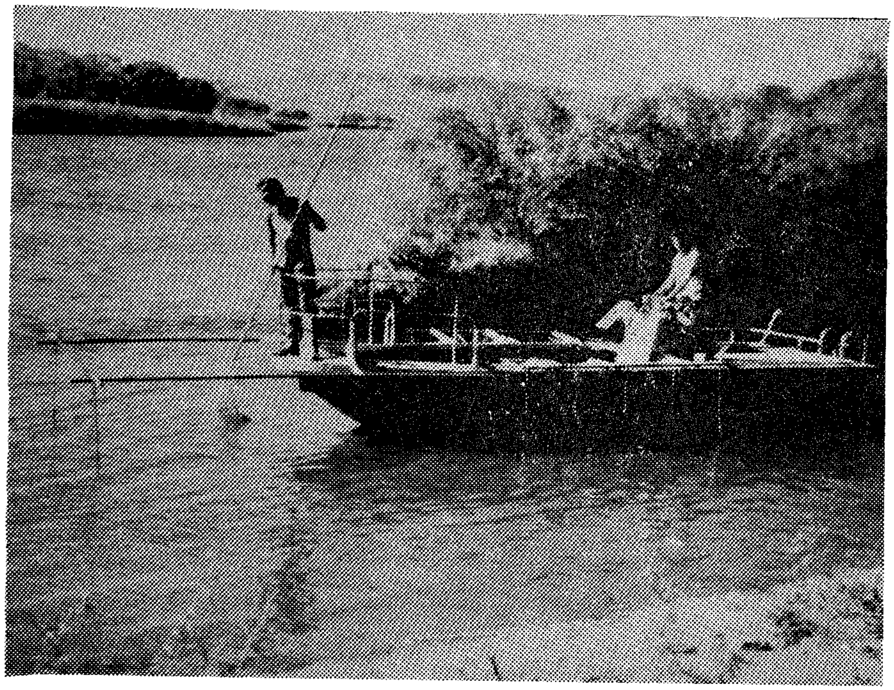


Figure 4. Boom suspended electrofishing apparatus mounted on a 6.7 m aluminum boat was used for sampling fish populations in the Missouri River.

fish with dip nets.

The electrode system of the boat consisted of positive and negative arrays. Since the boat was intended primarily for operation with direct current, the electrode configurations were designed specifically for this operating mode. However, the electrode system was also adequate for operation in the alternating current mode.

The positive electrode system consisted of two anodes suspended from fiberglass booms approximately 1.8 m (6 ft.) ahead of the bow of the boat. The booms were spread 2.1 m (7 ft.) apart and were adjustable for height by means of pin-locked adjustments. Each anode consisted of either (1) a spherical electrode, 38.1 cm (15 in.) in diameter, constructed from 1.0 cm (3/8 in.) diameter copper tubing or (2) an array of 12 to 15 "dropper" electrodes clipped to a 0.9 m (3 ft.) diameter aluminum support ring. The support ring provided mechanical support and an electrical connection for the droppers which actually carried the current into the water. Individual "droppers" consisted of 15.2 cm (6 in.) lengths of 1.6 cm (5/8 in.) diameter stainless steel tubing supported by a 45.7 cm (18 in.) length of heavy gauge insulated copper wire with a 20-amp test clip to attach to the support ring. By moving a sleeve of insulating material (1.6 cm [5/8 in.] diameter auto wire loom), exposure of the stainless steel "droppers" could be adjusted for waters of varying conductivity.

The negative electrode system consisted of two cathode arrays, one mounted on each side of the boat. Each array consisted of a set of five 1.2 m (4 ft.) lengths of 1.9 cm (3/4 in.) diameter flexible conduit supported

by a 2.4-m(8 ft.) length of fiberglass boom. Each length of conduit was fastened to the support boom by a chain and rubber insulator. The top of each length of conduit was insulated with electrical tape to reduce an unnecessary electrical field near the surface of the water.

Power was supplied to the positive and negative electrodes through 1.3 cm (1/2 in.) diameter metal conduit and watertight junction boxes. Industrial duty electronic plugs and receptacles (screw-in type) provided positive watertight connections between junction boxes, electrodes, and power source.

The power source for the electrofishing system was a 2,500-watt, 230-volt (60 Hz. single phase) alternating current generator. A Coffelt Model VVP-15 rectifying unit was used to change the alternating current to various forms of pulsed or continuous direct current. Output from the rectifying units could be varied from 0 to 600 volts and from 0 to 25 amps. Pulse frequency was adjustable from 20 to 200 pulses per second and pulse width from 20 to 80 percent. Meters were used to monitor all voltages, current output, frequency and pulse width.

Most of the aquatic habitat of the Missouri River in the study area consisted of deep mainstem areas with a few large side channels and backwaters. The boom-suspended electrofishing apparatus was the most effective technique for sampling these areas. Other procedures such as mobile electrofishing apparatus, gill nets, hoop nets, frame traps, and seining were effective only in restricted habitat areas such as shorelines, quiet pools, backwaters, and small side channels.

Mobile Electrofishing Apparatus

A mobile electrode apparatus was used for sampling fish populations in the lower Marias River and in shallow, restricted side channel and backwater areas of the Missouri River. Maneuverability of the relatively small mobile unit in these confined habitat areas proved highly advantageous.

The mobile electrofishing unit consisted of a 4.3 m (14 ft.) fiberglass boat containing a hand-held mobile positive electrode, a stationary negative electrode (fastened to the bottom of the boat) and a portable 2,500-watt, 115-volt (60 Hz. single phase) alternating current generator. A Fisher Model FS-103 rectifying unit was used to change the alternating current to various forms of pulsed or continuous direct current. The direct current output was adjustable from 0 to 500 volts. A 40 hp jet outboard was used for mobility in deep water areas where the electrofishing boat could not be maneuvered by hand.

Gill Nets

Fish were also captured with standard experimental sinking nylon gill nets 1.8 x 38.1 m (6 x 125 ft.) with graduated mesh size from 1.9 to 5.1 cm (3/4 to 2 in.) square measure. Overnight stationary sets with these nets in areas of the river with little or no current, generally produced good catches of a wide variety of fish species. Stationary gill net sets in areas of the river with any significant amount of current were largely unsuccessful because the nets usually became badly fouled with debris and, in some cases, were washed downstream by the current.

In some main channel areas of the Missouri River with moderate current, heavy-duty, large-mesh sinking nylon gill nets were drifted perpendicular to the current in an attempt to capture fish. These nets were 2.4 m (8 ft.) deep and varied in length from 15.2 to 45.7 m (50 to 150 ft.). The nets could be drifted only in areas of the river relatively free from snags and with sufficient current to carry the nets. In many areas, the current was too swift for drifting the nets.

Drifting gill nets with 7.6 cm (3 in.) square measure mesh was effective and fairly selective for sampling shovelnose sturgeon and blue suckers. Paddlefish were taken readily by drifting gill nets with 12.7 cm (5 in.) square measure mesh in the Missouri River below Robinson Bridge. The 12.7 cm mesh appeared to be exclusively selective for paddlefish.

Baited Hoop Nets

Baited hoop nets were used to sample channel catfish in the study area. The nets were constructed of 3.2 cm (1.25 in.) square mesh, tarred, nylon netting on a matched set of four 0.8 m (2.5 ft.) diameter wood hoops with an overall length of 2.0 m (Figure 5). This type of hoop net had been used successfully by commercial fishermen to capture channel catfish in the Missouri and Mississippi rivers (Ragland and Robinson 1972, Helms 1973). The nets were fairly selective for channel catfish although a few other species were occasionally taken.

The hoop nets were set in the river with the open throat facing downstream. A bait bag containing from ½ to 1 kilogram (kg) of rotten cheese was attached to the bottom of the rear hoop inside the net. The bait bags were constructed from rubber tire inner tubes perforated as much as possible to help feed the bait. A weight of from 20 to 50 kg was attached to the rear of the net. This weight anchored the hoop net on the streambottom. The exact amount of weight required to anchor the net depended on the force of the current. A second weight of about 2 kg was attached to the bottom of the front hoop to keep the net stretched in position on the streambottom. A 3 to 6 m nylon line with a buoy was attached to the top of the front hoop to mark the location of the set.

The most important element in sampling for channel catfish in large rivers is to locate the specific site for the net. The lack of success in capturing catfish is usually due to net location rather than to inefficiency of the hoop net or bait.

Net location varies to some extent with the seasonal distribution of channel catfish. From about mid-March through mid-June, a substantial number of catfish were found in side channels of the Missouri River in pools near undercut banks. A limited number of sets were made in these areas during spring. However, it was generally impractical to set hoop nets in the Missouri River during spring because of the great amount of debris carried by the river. As stream flow levels rose, the nets often became badly fouled with debris and, in some cases, were washed downstream by the current.

The best results in sampling for channel catfish in the Missouri River were obtained during the period from mid-June through late October. Most of the channel catfish were found in deep pools in main channel areas in or near the thalweg during this time period. The nets were placed on stable

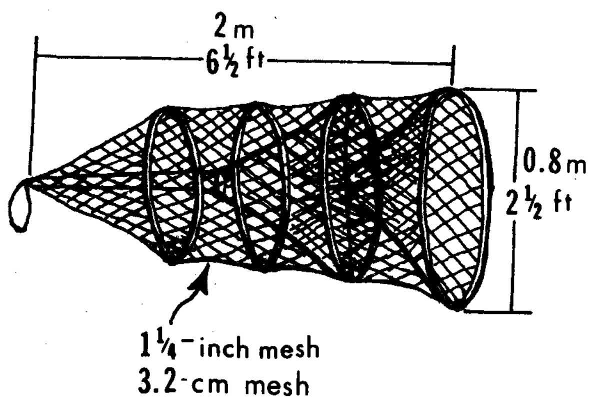


Figure 5. Baited hoop nets were used to sample channel catfish in the Missouri, Marias, and Teton rivers.

gravel or sand and gravel substrate at the head of the larger pools in water at least 1.5 m (5 ft.) deep. Nets placed on unstable substrate, such as sand or mud, usually resulted in poor catches and often became partially buried and were difficult to retrieve. To facilitate feeding out of the bait the nets were placed in areas with current velocity as swift as possible without washing away the nets.

The first nets set in each section were left in the water for 48 to 72 hours to allow sufficient time for the bait to feed out. The nets were then raised and data on the catch recorded. After the first set, the nets were checked approximately once every 48 hours. Information on the time of setting and raising, correct to the nearest five minutes was recorded for each net.

Frame Traps

Spawning migrations of sauger and other species were monitored on the lower Marias River with 0.9 m (3 ft.) high by 1.2 m (4 ft.) long frame traps (Figure 6). The traps were constructed from 2.5 cm (1 in.) square mesh fence wire and 1.3 cm (½ in.) diameter reinforcing rod material. Similar traps were used successfully by Posewitz (1963) to capture fish in the middle Missouri River and the lower reaches of its tributaries.

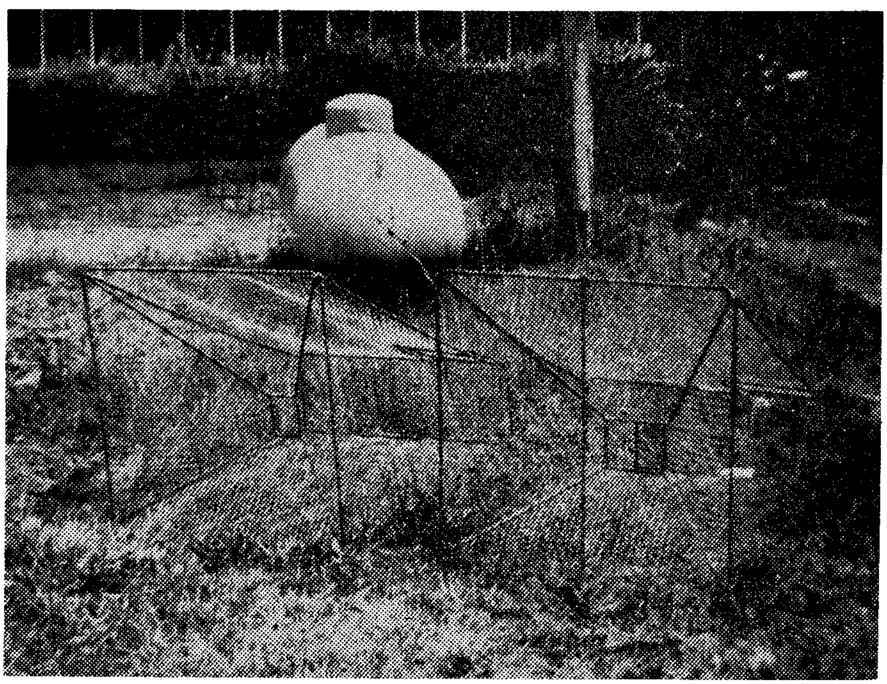


Figure 6. Spawning migrations of sauger in the lower Marias River were monitored with frame traps.

The frame traps were set in the river with the open throat facing downstream. One or two lead nets, 0.9 to 1.8 m (3 to 6 ft.) high, with 2.5 cm (1 in.) square mesh and from 3 to 15 m long, were stretched at various angles downstream from the trap. The angle depended on the force of the current.

The frame traps were successful for sampling a substantial number of migrating adult game fish, especially sauger, during their spawning seasons. Posewitz (1962) believed the traps were selective for adult sauger in the lower Marias River. Selectivity toward adults was probably due to the relatively large square mesh 2.5 cm (1 in.) of the traps and leads. Ricker (1971) reported that underwater frame traps are selective by species, and have been selective for the larger fish of a size class above the minimum imposed by the physical dimensions of the net. Traps and leads of a mesh size smaller than 2.5 cm cannot be fished effectively in the Missouri River because they impede streamflow, trap debris, and are washed out much more easily than the large mesh.

Seines

Forage fish samples were collected with 15.2 x 1.2 m (25 x 4 ft.) beach seines with 6.4 and 3.2 mm (1/4 and 1/8 in.) square mesh. The seine was operated by two persons and worked in as many different habitat types as the current and bottom characteristics allowed. Most of the seining sites were confined areas, such as backwaters and side channels, where the presence of forage fish was anticipated. Some forage fish were also taken in selected unconfined portions of the open river, such as shoreline and shallow riffle areas. Fish collected were identified and associated habitat types were recorded.

Fish Sample Processing and Tagging

Fish captured by the various techniques were anesthetized with MS-222, measured to the nearest millimeter in total length, and weighed to the nearest 10 grams (g). In addition, paddlefish and shovelnose sturgeon were measured to the nearest millimeter in fork length. Sex and spawning condition (gravid, ripe, or spawned) were recorded for fish captured during their spawning season. All fish were released near the capture site.

In addition to the above, several fish species were marked with individually numbered tags. Tag return data were used to provide an indication of angler harvest rates and to determine movement patterns of individual fish, particularly spawners, and establish their home ranges.

Individually numbered, plastic, cinch-up spaghetti tags, anchored through the base of the adipose fin, were used to mark channel catfish. Shovelnose sturgeon were tagged with individually numbered, monel, wing band tags clipped over the anterior rays of the pectoral fin or with individually numbered, plastic, cinch-up spaghetti tags inserted through the posterior portion of the fleshy keel at the base of the dorsal fin. All other game fish species and several nongame species, including blue suckers, bigmouth buffalo, smallmouth buffalo, and freshwater drum were tagged with individually numbered Floy T-tags inserted near the base of the dorsal fin. Information signs were placed at accessible points along the river in an effort to encourage anglers to provide information about tagged fish in their creel.

Age and Growth

Scales or other structures were taken from certain fish species for age and growth determination. Scale samples were taken regularly from sauger, blue suckers, bigmouth and smallmouth buffalo, and freshwater drum. Small numbers of scales were also collected from walleye, northern pike, rainbow and brown trout, and mountain whitefish. The scale samples were imprinted on an acetate slide, and the imprints were projected at 44X on a Norwest nmi 90 microfiche reader. Annuli were identified and ages assigned following criteria in Tesch (1971) and Lagler (1956).

Annuli measurements in millimeters for back calculations were made from the center of the focus of each scale along the central radius to the anterior edge of the scale. Calculations of length at previous annuli for fish 0 to 10 years old were made at the Montana State University computer center using a modified version of FIRE I, a fisheries statistics program. This program employs the Dahl Lea, Rosa Lea, and corrected Rosa Lea linear back calculation equations and the Monastyrsky logarithmic equation (Tesch 1971). FIRE I was also used to summarize empirical data concerning length, weight, percent composition, and condition factors of assigned age groups. It also calculated length-weight and length-scale radii relationships. Condition factors (K_{TL}) were calculated by the forumula:

$$K_{TL} = \frac{W \times 10^5}{L^3}$$

Dentarys (lower jaws) were collected from a number of angler harvested paddlefish during creel census surveys conducted on the Missouri River in the Slippery Ann area. The dentarys were placed in chlorine bleach for several days to remove the flesh and then dried in an oven set at 50 degrees centigrade (C). The dentarys were then cut into thin cross sections, 30 to 40 micra thick, with a jeweler's saw. Because of the greater thickness of the dentary at the point where it bends mesially, cross sections were made in this area (the caudio mesiad) to provide the widest area for counting growth rings. The sections were smoothed on garnet paper and immersed in glycerin prior to being examined under a 30X stereoscope. Annuli were then counted in the manner described by Adams (1942).

Pectoral spines were collected from channel catfish for age and growth determination. The spines were sectioned with a small power saw apparatus similar to that described by Witt (1961). Sections of the spines were made just distal to the basal groove as suggested by Sneed (1951). The sections were sanded to less than 0.05 mm in thickness and emersed in a dilute solution of hydrochloric acid for partial decalcification. The sections were then washed in tap water and placed in glycerin between two microscope slides. The mounted sections were projected at 44X on a Norwest nmi 90 microfiche reader for age and growth determinations.

The magnified spine sections clearly showed narrow transparent bands separated by wider, opaque bands. The narrow, transparent bands were deposited by slower winter growth and were considered annuli. Measurements were made in millimeters from the center of the lumen to each annulus and to the edge of the spine section along the axis of the longest anterior lobe as suggested by Sneed (1951). The articulating process of each spine was sectioned, wetted with xylene and viewed with reflected light under a binocular microscope. Under reflected light the annuli appeared as narrow, dark banks. These sections were used to check ages assigned to spine sections taken distad

to the basal groove as suggested by Ragland and Robinson (1972). The sections made through the articulating process retained all annual marks, while sections made through the spine distad to the basal groove were missing annuli due to enlargement of the spine lumen. Age and growth calculations were made using methods previously described for scaled fish.

Pectoral fin rays of shovelnose sturgeon were sectioned and examined for age determination. Three sections of each ray were made, beginning approximately 12 mm distad from the articulation and proceeding proximally toward the articulation. Roussow (1957) and Cuerrier (1951) sectioned shovelnose sturgeon pectoral rays 13 mm or closer to the base. Zweiacker (1967) made the first sections 20 mm from the base and proceeded proximally. The shovelnose sturgeon pectoral sections were then prepared and mounted as described above for channel catfish. The cross section of the marginal anterior ray of the pectoral fin was used to age the sturgeon. Annuli apppeared as narrow, translucent, single or banded lines. No attempt was made to back calculate shovelnose sturgeon lengths at previous annuli because of their old age and the close compaction of their annuli.

Complete decalcification, microtome sectioning and mounting with Giensa stain proved unsatisfactory for viewing annuli on channel catfish and shovelnose sturgeon pectoral cross sections. This process tended to obliterate the annuli.

Creel Census and Creel Survey

Paddlefish Creel Census

A creel census study was conducted on the paddlefish fishery on the Missouri River immediately upstream from Fort Peck Reservoir during the spring of 1977. The creel census method was adapted largely from Needham (1973). Based on field tests of various creel census methods, Needham selected this technique because it was the most reliable one for the Missouri River study area.

Creel census data were collected on as many days as possible throughout the entire spring paddlefish snagging season. Weekends and holidays received much heavier fishing pressure than weekdays. Therefore, a larger proportion of weekends and holidays were creel censused than weekdays. Estimates of fisherman pressure and catch on noncensus days were based on data from preceding and following census days. In addition, some information on pressure and harvest on noncensus days was provided by US Fish and Wildlife Service personnel stationed on the Charles M. Russell National Wildlife Range, which borders the study area and by DFWP wardens.

As many anglers as possible were interviewed after completing their fishing day. On most days, the absolute number of fishermen and their harvest could be determined. Data recorded on angler interviews included angler residency, length of trip, estimated time spent fishing, method of fishing (bank or boat), number of paddlefish caught, and number of paddlefish kept.

As much of the creel as practical was measured to the nearest centimeter in length, fork length, and eye-to-fork length. Weights were determined to the nearest 0.5 kg with a Chatillon Model 100A straight spring scale. Sex was determined by weight, body configuration, presence of tubercules and examination of the gonads and urogenital pore.

A number of paddlefish in good condition which were caught by anglers who did not wish to keep them, were tagged and released near the capture site. The tags used were individually numbered, monel, poultry bands anchored around the dentary (lower jaw) near its symphysis. Tag returns provided information on angler harvest rates and movements.

Missouri River Creel Survey

An angler creel survey was conducted during 1977 and 1978 on the sport fishery which exists on the Missouri River from Great Falls to Fort Peck Reservoir. This survey was a partial census in which interviews of fishermen were used to obtain estimates of angling data. The survey technique, formulated with the assistance of George Holton, Fisheries Division, DFWP, used a fish species identification chart and postcard-sized angler survey forms (Appendix Figures 1 and 2).

The angler survey forms were of two different types - "voluntary" and "interview." The "voluntary" survey form relied on voluntary compliance in answering the survey and returning the postpaid card. "Voluntary" forms were distributed to parties of anglers by personnel from the Bureau of Land Management (BLM), Lewistown, and Northwestern University, Evanston, Illinois, during the course of their recreational use surveys on the river.

With the "interview" survey form, partial trip data were obtained during interviews with individual anglers. The "interview" form was recorded in duplicate, with the original copy retained by the census taker and the carbon copy given to the angler. Upon completion of his/her fishing trip, the angler voluntarily recorded complete trip data and returned the postpaid carbon copy of the "interview" form. As many interviews as possible were obtained during the course of the research, such as electrofishing and gill netting on the river. In addition, a number of days, especially weekends and holidays, were devoted exclusively to collecting creel survey data.

Data recorded on the angler survey forms included residency, party size, length of trip, estimated time spent fishing, type of fishing (bank or boat), method of fishing (setline, angling, or snagging), type of lure used, and number and kind of fish kept and released.

FINDINGS - AQUATIC HABITAT PARAMETERS

Drainage Area and Stream Discharge

The drainage area of the middle Missouri River increases from 60,326 km^2 to 106,156 km^2 or by about 76 percent, between Morony Dam and Robinson Bridge (United States Geological Survey 1979). However, due to the semi-arid climate, the increase in mean annual streamflow is only about 17 percent. The climate is characterized by moderately low rainfall, a dry atmosphere, hot summers, cold winters, and a large proportion of sunny days (Gieseker 1931). Precipitation averages about 33 cm (13 in.) annually, of which about 22 cm falls during May through September (Misssouri River Joint Study 1963).

Streamflow regimes are monitored by the US Geological Survey (USGS) at Morony Dam, Fort Benton, Coal Banks Landing, and Robinson Bridge. Mean annual discharge for a 22-year period of record at Morony Dam, an 88-year period of record at Fort Benton, a 43-year period of record at Coal Banks

Landing, and a 44-year period of record at Robinson Bridge were 7.12 km^3/y (5,776,000 AF/y), 6.95 km^3/y (5,636,000 AF/y), 7.70 km^3/y (6,242,000 AF/y), and 8.35 km^3/y (6,775,000 AF/y) respectively (USGS 1979). The maximum flows recorded at the four stations, respectively, were 2,040 m^3/sec (72,000 cfs) on June 10, 1964, 3,960 m^3/sec (140,000 cfs) on June 6, 1908, 3,460 m^3/sec (122,000 cfs) on June 5, 1953, and 3,880 m^3/sec (137,000 cfs) on June 6, 1953. The recorded minimums were 0.028 m^3/sec (1 cfs) on April 16, 1962, at Morony Dam in response to a power plant shutdown, 9.06 m^3/sec (320 cfs) on July 5, 1936, at Fort Benton, 18.1 m^3/sec (638 cfs) on July 5, 1936, at Coal Banks Landing and 31.7 m^3/sec (1,120 cfs) on July 8, 1936 at Robinson Bridge. The present day flow regimens are not natural because of regulation and storage at several dams in the drainage upstream from the study area.

Stream Gradient and Velocity

The Missouri River enters the study area immediately below Morony Dam at an elevation of 856.2 m (2,809 ft.) msl, dropping 167.6 m (550 ft.) to an elevation of 688.5 m (2259 ft.) msl at Robinson Bridge. Stream gradient averages 0.57 m/km (3.0 ft./mi.) and varies from over 1.9 m/km (10 ft./mi.) in the extreme upper reaches to less than 0.4 m/km (2 ft./mi.) in some sections (Table 1). A longitudinal profile from Morony Dam to Fort Peck Reservoir is shown in Figure 7. Stream gradients were determined by measurements taken from USGS topographic maps (1:24,000 scale). A river distance chart, also taken from the topographic map, is presented in Appendix Table 1.

Velocity is closely associated with stream width, discharge, and gradient. Mean velocities range from about 1.1 to 0.6 m/sec (3.5 to 2.0 ft./sec.) at a discharge of 169.9 m^3/sec (600 cfs) (USDI 1975).

Water Temperature

Water temperatures were monitored during the ice-free period by continuous recording thermograph stations located on the Missouri River at Morony Dam, Fort Benton, Coal Banks Landing, and Robinson Bridge and on the Marias River 5.1 m upstream from the mouth. The daily maximum and minimum water temperatures recorded at each station from 1976 through 1979 are shown in Appendix Tables 2 through 17. The Coal Banks Landing station was operated by the USGS. The others were maintained by the DFWP.

Each year, at the five stations, water temperature warmed progressively from late March through early June. The highest annual water temperatures were achieved from early June through mid-August. The highest temperatures recorded at the Morony Dam, Fort Benton, Coal Banks Landing, and Robinson Bridge stations during the study period were 20.0, 26.1, 26.7, and 26.7 C (68, 79, 80, and 80 F), respectively. The highest temperature recorded on the Marias River was 28.9 C (84 F).

Water temperatures were monitored from 1976 through 1979 at Fort Benton, Coal Banks Landing, and Robinson Bridge. The Marias River was monitored from 1977 through 1979, and Morony Dam was monitored only in 1977.

Water temperature at the Coal Banks Landing and Robinson Bridge stations from late July through early November 1976 averaged 0.22 and 0.17 C (0.4 and 0.3 F) degrees higher, respectively, than the Fort Benton station. The mean diurnal differences between the average maximum and average minimum water temperatures were 2.52, 2.26 and 1.26 C (4.53, 4.07 and 2.26 F) degrees for the Fort Benton, Coal Banks Landing, and Robinson Bridge stations, respectively.

Table 1. Stream gradients of the middle Missouri River from Morony Dam to Fort Peck Reservoir. Confluence of the Missouri River with the normal flood pool of Fort Peck Reservoir is kilometer 0.0.

River Kilometer	Approximate Location	Elevation (meters, msl)	Gradient (m/km)	Gradient (ft/mi)
333.1	Morony Dam	856.2	-	-
331.9		853.4	3.11	16.41
330.2	Belt Creek	847.3	3.54	18.69
326.8		841.2	1.77	9.34
323.7	Highwood Creek	835.2	2.05	10.81
316.2		829.1	0.79	4.19
309.2		823.0	0.88	4.66
304.3	Carter Ferry	816.9	1.21	6.41
297.7		810.8	0.92	4.88
289.5		804.7	0.75	3.95
282.2	Fort Benton	798.6	0.84	4.45
270.9		792.5	0.54	2.84
261.5		786.4	0.65	3.41
254.9		780.3	0.92	4.88
240.4	Marias River	774.2	0.42	2.20
225.3		768.1	0.40	2.13
203.7	Little Sandy Creek	762.0	0.28	1.49
188.7		755.9	0.40	2.13
173.0	Hole-in-the-Wall	749.8	0.39	2.05
158.8		743.7	0.44	2.30
148.2		737.6	0.57	3.01
133.5	Judith River	731.5	0.42	2.20
113.3	Stafford Ferry	719.3	0.60	3.17
90.6		707.1	0.53	2.82
65.6	Cow Island	694.9	0.49	2.59
37.3	Robinson Bridge	688.5	0.39	2.08
0.0	Fort Peck Reservoir	684.6	0.16	0.83

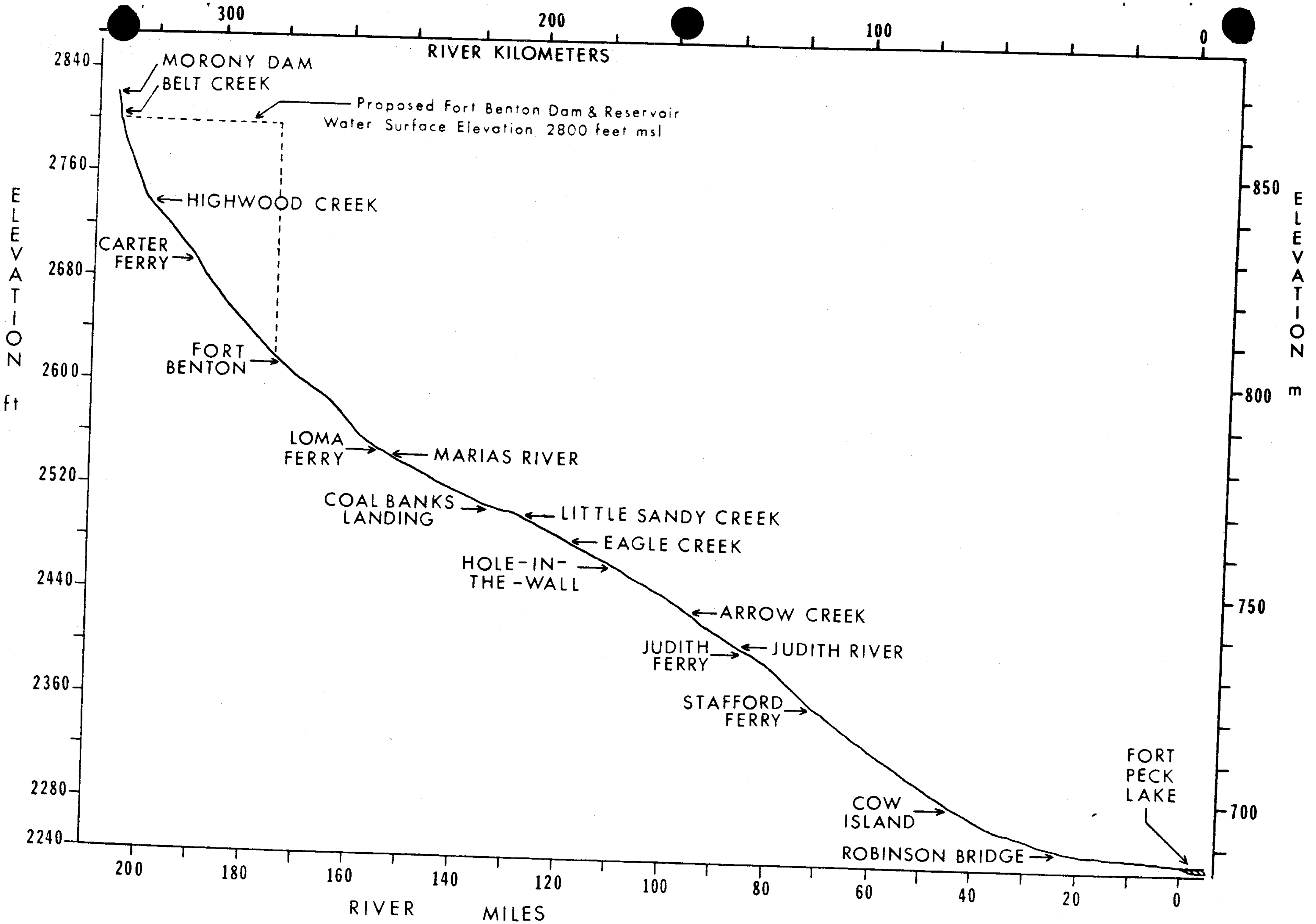


Figure 7. Longitudinal profile of the Missouri River from Morony Dam to Fort Peck Reservoir.

In 1977, water temperatures at the Coal Banks Landing and Robinson Bridge stations from mid-April through early November averaged 1.2 and 1.0 C (2.1 and 1.8 F) degrees higher, respectively, than the Fort Benton station. At the Morony Dam station during 1977, a shorter period of record was available than for the other three Missouri River stations. However, during a period of record from early June through early September, 1977, water temperature at the Morony Dam station averaged 3.7 C (6.7 F) degrees lower than the Fort Benton station. During 1977, the mean diurnal differences between the average maximum and average minimum water temperatures were 2.83, 2.71, 2.44, and 2.14 C (5.10, 4.87, 4.39, and 3.86 F) degrees for the Morony Dam, Fort Benton, Coal Banks Landing, and Robinson Bridge stations, respectively.

In 1978, water temperatures at the Coal Banks Landing and Robinson Bridge stations from late April through mid-October averaged 0.2 and 1.7 C (0.4 and 3.1 F) degrees higher, respectively, than the Fort Benton station. During the same period of record in 1979, water temperatures at the Coal Banks Landing and Robinson Bridge stations averaged 0.3 C (0.5 F) degrees lower and 0.9 C (1.6 F) degrees higher, respectively, then the Fort Benton station. The colder water temperatures in 1979 at the Coal Banks Landing and Robinson Bridge stations are due to relatively cooler water temperatures of the Marias River in 1979. The mean diurnal differences between the average maximum and average minimum water temperatures at the Fort Benton, Coal Banks Landing, and Robinson Bridge stations, respectively were 2.13, 1.59, and 1.56 C (3.83, 2.87, and 2.81 F) degrees in 1978 and 2.38, 1.98, and 1.51 C (4.28, 3.57, and 2.72 F) degrees in 1979.

The Marias River enters the Missouri River between the Fort Benton and Coal Banks Landing stations. The average temperature of the Marias River from late April through mid-October was 16.8, 16.6, and 16.0 C (62.2, 61.9, and 60.9 F) in 1977, 1978, and 1979, respectively. By comparison

the water temperature of the Missouri River upstream from the Marias River at Fort Benton averaged 15.5, 15.6, and 17.2 C (59.8, 60.0, and 63.1 F) during the same periods in 1977, 1978, and 1979, respectively. The Marias River had a warming influence on the Missouri River in 1977 and 1978 and a cooling influence in 1979. The reversal in 1979 was due to abnormally large amounts of cold water being released from the bottom of Tiber Reservoir. The Marias River normally has a warming influence on the Missouri River during the ice-free period. The mean diurnal difference between the average maximum and average minimum water temperature is greater on the Marias River than on the Missouri River. The diurnal difference was 4.12, 4.07, and 2.97 C (7.42, 7.33, and 5.35 F) degrees in 1977, 1978, and 1979, respectively. By comparison the diurnal difference on the Missouri River at Fort Benton was 2.71, 2.13, and 2.38 C (4.87, 3.83, and 4.28 F) degrees in the same years.

Water Quality

Basic water quality parameters were monitored at six stations on the middle Missouri River during 1978 and 1979. The stations were located at Ulm (above Great Falls), below Morony Dam, at Fort Benton, at Coal Banks Landing, at Judith Landing, and at Robinson Bridge. The latter five stations were study sites for aquatic macroinvertebrates and fish.

Sampling "runs" were made during four periods:

(1) low flow, warm water - early August 1978,
(2) low flow, cool water - middle October 1978,
(3) after ice-out, prior to spring runoff - early April 1979, and
(4) near the peak of spring runoff - middle June 1979.

Stream flow in the Missouri River was near normal in 1978 and 1979. Therefore, the water quality findings should be representative of average conditions. Results of the water quality analyses are shown in Table 2.

In general, chemical constituent values progressively increased downstream at the six stations. Concentrations of most of the major ions, including calcium, magnesium, sodium, bicarbonate, and sulfate, were moderately high at all stations during all sampling periods. In general, the Missouri River contains two or three times more total dissolved solids than "average" river water as described by Livingstone (1963). However, the concentrations of two major ions, chloride and carbonate, were near normal on the Missouri River when compared to other rivers.

Reid (1961) developed the following classification scheme for potential biological productivity based on calcium ion concentration:

Ca^{++} concentration	Potential biological productivity
Less than 0.50 me/l	Poor
0.50 - 1.25 me/l	Medium
Greater than 1.25 me/l	Rich

Calcium ion concentrations of the Missouri River during our sampling ranged from 1.796 to 3.942 me/l. Therefore, by these criteria, the potential biological productivity of the Missouri River in the study area is very good.

Table 2. Water quality measurements at six stations on the mainstem of the middle Missouri River, 1978-79.

Water Quality Parameter	Ulm Bridge	Morony Dam	Fort Benton	Coal Banks	Judith Landing	Robinson Bridge
	SAMPLING STATION					
	Low flow, warm water - August 1, 1978					
Calcium (mg/l Ca)	36.0	41.0	42.0	46.0	53.0	53.0
Magnesium (mg/l Mg)	11.0	13.0	14.0	17.0	18.0	18.0
Sodium (mg/l Na)	19.0	19.0	20.0	30.0	35.0	44.0
Sum Cations (meq/l)	3.528	3.942	4.117	4.999	5.648	6.039
Bicarbonate (mg/l HCO_3)	164.7	174.5	164.7	153.7	161.0	161.0
Carbonate (mg/l CO_3)	0.0	0.0	0.0	4.8	0.0	0.0
Chloride (mg/l Cl)	0.9	8.9	9.0	8.6	9.6	9.3
Sulfate (mg/l SO_4)	31.1	49.2	53.5	95.1	131.0	148.0
Phosphate (mg/l PO_4)	0.009	0.014	0.034	0.012	0.026	0.028
NO3 + NO2 (mg/l Tot N)	$<$0.01	0.04	$<$0.01	$<$0.01	$<$0.01	0.08
Sum Anions (meg/l)	3.374	4.139	4.070	4.903	5.640	5.991
Laboratory pH	8.05	8.08	7.99	8.67	8.04	7.98
Total Diss. Ions (mg/l)	262.7	305.6	303.2	355.2	407.7	433.4
Conductivity (umhos/cm)	340.5	385.5	395.5	462.7	541.7	575.9
Total Hard. (mg/l)	135	156	163	185	206	206
Total Alk. (mg/l)	135	143	135	134	132	132
Turbidity (NTU)	5.5	12	82	19	205	340
Na Adsorption Ratio	0.7	0.7	0.7	1.0	1.1	1.3
Tot. Susp. Sediment (mg/l)	14.1	26.7	266.2	55.2	598.0	1397.4
Cadimum, TR (mg/l Cd)	$<$0.001	$<$0.001	0.001	$<$0.001	$<$0.001	$<$0.001
Lead, TR (mg/l Pb)	$<$0.005	0.009	0.010	0.010	$<$0.010	$<$0.010
Tot. Phosphorous (mg/l P)	0.028	0.059	0.660	0.076	0.368	0.180
Tot. Nitrogen, KJL (mg/l N)	-	-	-	-	-	0.15
Manganese, TR (mg/l Mn)	0.035	0.045	0.220	0.050	0.140	0.270
Aluminum, TR (mg/l Al)	0.3	0.3	0.8	0.3	1.1	2.1
Arsenic, TR (mg/l As)	0.016	0.011	0.015	0.010	0.009	0.006
Copper, TR (mg/l Cu)	$<$0.01	$<$0.01	0.02	0.02	0.02	0.04

Table 2 continued. Water quality measurements at six stations on the mainstem of the middle Missouri River, 1978-79.

Water Quality Parameter	SAMPLING STATION Ulm Bridge	Morony Dam	Fort Benton	Coal Banks	Judith Landing	Robinson Bridge
	Low flow, warm water - August 1, 1978					
Zinc, TR (mg/l Zn)	< 0.005	0.005	0.095	< 0.005	0.022	0.041
Iron, TR (mg/l Fe)	0.15	0.24	1.90	0.36	1.50	3.20
Tot. Ammonia (mg/l N)	< 0.01	0.03	0.06	0.01	0.11	0.02
	Low flow, cool water - October 11 & 12, 1978					
Calcium (mg/l Ca)	37.0	45.0	45.0	46.0	48.0	54.0
Magnesium (mg/l Mg)	11.0	16.0	16.0	16.0	18.0	19.0
Sodium (mg/l Na)	17.0	18.0	18.0	26.0	25.0	35.0
Sum Cations (meq/l)	3.491	4.345	4.345	4.743	4.963	5.780
Bicarbonate (mg/l HCO_3)	146.4	175.7	164.7	164.7	164.7	178.1
Carbonate (mg/l CO_3)	0.0	0.0	0.0	0.0	0.0	1.9
Chloride (mg/l Cl)	9.8	7.6	7.2	7.0	7.3	7.5
Sulfate (mg/l SO_4)	34.9	62.7	63.0	93.6	93.9	137.0
Phosphate (mg/l PO_4)	0.034	0.033	0.026	0.012	0.011	0.006
NO3 + NO2 (mg/l Tot N)	< 0.01	0.07	< 0.01	< 0.01	< 0.01	< 0.01
Sum Anions (meq/l)	3.406	4.407	4.216	4.847	4.861	6.048
Laboratory pH	8.02	8.10	8.03	8.09	8.12	8.28
Total Diss. Ions (mg/l)	256.1	325.1	313.9	353.3	356.9	432.5
Conductivity (umhos/cm)	350.4	424.0	427.6	485.5	485.4	576.0
Total Hard. (mg/l)	138	178	178	181	194	213
Total Alk. (mg/l)	120	144	135	135	135	149
Turbidity (NTU)	0.7	2.1	0.1	4.5	4.0	12.0
Na Adsorption Ratio	0.6	0.6	0.6	0.8	0.8	1.0
Tot. Susp. Sediment (mg/l)	5.8	9.8	14.6	17.5	17.9	61.2
Cadmium, TR (mg/l Cd)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lead, TR (mg/l Cd)	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Tot. Phosphorous (mg/l P)	0.040	0.070	0.048	0.050	0.030	0.064
Tot. Nitrogen, KJL (mg/l N)	0.09	0.56	0.48	0.24	0.08	0.51

Table 2 continued. Water quality measurements at six stations on the mainstem of the middle Missouri River, 1978-79.

Water Quality Parameter	Ulm Bridge	Morony Dam	Fort Benton	Coal Banks	Judith Landing	Robinson Bridge
	SAMPLING STATION					
	Low flow, cool water - October 11 & 12, 1978					
Manganese, TR (mg/l Mn)	0.025	0.030	0.035	0.030	0.025	0.040
Aluminum, TR (mg/l Al)	0.20	0.20	0.20	0.20	0.20	0.20
Arsenic, TR (mg/l As)	0.017	0.014	0.014	0.011	0.011	0.009
Copper, TR (mg/l Cu)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc, TR (mg/l Zn)	<0.005	<0.005	0.005	0.005	0.005	0.005
Iron, TR (mg/l Fe)	0.05	0.08	0.16	0.13	0.15	0.40
Tot. Ammonia (mg/l N)	<0.01	0.01	0.02	<0.01	<0.01	<0.01
	After ice-out, prior to spring runoff - April 2 & 3, 1979					
Calcium (mg/l Ca)	43.8	49.2	53.1	55.5	-	68.8
Magnesium (mg/l Mg)	13.6	18.7	26.0	24.1	-	32.7
Sodium (mg/l Na)	21.0	24.0	38.0	37.0	-	66.0
Sum Cations (meq/l)	4.218	5.037	6.442	6.362	-	8.994
Bicarbonate (mg/l HCO_3)	175.4	191.5	194.0	198.9	-	211.1
Carbonate (mg/l CO_3)	1.7	0.0	0.0	0.0	-	0.0
Chloride (mg/l Cl)	10.3	10.0	10.8	9.7	-	11.6
Sulfate (mg/l SO_4)	43.0	77.3	151.0	142.0	-	244.0
Phosphate (mg/l PO_4)	0.014	0.020	0.020	0.014	-	0.028
NO3 + NO2 (mg/l Tot N)	0.18	0.23	0.29	0.34	-	0.58
Sum Anions (meq/l)	4.131	4.795	6.650	6.515	-	8.910
Laboratory pH	8.27	8.14	8.16	8.15	-	8.20
Total Diss. Ions (mg/l)	309.0	362.0	473.2	467.5	-	634.8
Conductivity (umhos/cm)	423.0	497.0	644.0	631.0	-	850.0
Total Hard. (mg/l)	165	200	240	238	-	306
Total Alk. (mg/l)	147	157	159	163	-	173
Turbidity (NTU)	4.0	6.2	9.0	-	-	90
Na Adsorption Ratio	0.7	0.7	1.1	1.0	-	1.6
Tot. Susp. Sediment (mg/l)	-	-	-	34.0	-	-

Table 2 continued. Water quality measurements at six stations on the mainstem of the middle Missouri River, 1978-79.

Water Quality Parameter	Ulm Bridge	Morony Dam	Fort Benton	Coal Banks	Judith Landing	Robinson Bridge
	SAMPLING STATION					
	After ice-out, prior to spring runoff - April 2 & 3, 1979					
Cadimum, TR (mg/l Cd)	<0.001	<0.001	<0.001	<0.001	-	<0.001
Lead, TR (mg/l Pb)	<0.005	<0.005	<0.005	<0.005	-	<0.005
Tot. Phosphorous (mg/l P)	0.040	0.040	0.040	0.070	-	0.190
Tot. Nitrogen, KJL (mg/l N)	0.26	0.39	0.45	0.37	-	0.66
Manganese, TR (mg/l Mn)	0.035	0.030	0.050	0.045	-	0.075
Aluminum, TR (mg/l Al)	0.20	0.20	0.30	0.50	-	1.50
Arsenic, TR (mg/l As)	0.020	0.015	0.014	0.010	-	0.009
Copper, TR (mg/l Cu)	<0.01	<0.01	<0.01	<0.01	-	<0.01
Zinc, TR (mg/l Zn)	<0.005	0.010	0.010	0.013	-	0.013
Iron, TR (mg/l Fe)	0.16	0.32	0.39	0.94	-	2.00
Tot. Ammonia (mg/l N)	<0.01	0.02	0.01	0.01	-	0.02
	Near peak of spring runoff - June 15 & 19, 1979					
Calcium (mg/l Ca)	44.0	51.4	48.7	49.3	49.3	50.0
Magnesium (mg/l Mg)	10.9	16.8	13.2	19.7	18.4	20.2
Sodium (mg/l Na)	17.3	20.0	23.4	30.5	25.9	27.4
Sum Cations (meq/l)	3.845	4.817	4.534	5.407	5.100	5.349
Bicarbonate (mg/l HCO_3)	173.2	185.4	162.3	190.3	170.2	176.9
Carbonate (mg/l CO_3)	0.0	1.2	0.0	0.0	5.4	4.8
Chloride (mg/l Cl)	9.8	7.9	7.4	8.2	7.8	8.1
Sulfate (mg/l SO_4)	42.8	62.0	83.9	103.0	84.9	102.0
Phosphate (mg/l PO_4)	0.037	0.037	0.910	0.033	0.030	0.046
NO3 + NO2 (mg/l Tot N)	0.10	0.13	0.29	0.05	0.02	<0.01
Sum Anions (meq/l)	4.017	4.606	4.724	5.502	4.961	5.416
Laboratory pH	8.20	8.30	7.90	8.50	8.50	8.50
Total Diss. Ions (mg/l)	298.2	344.9	340.1	401.1	361.9	389.4
Conductivity (umhos/cm)	389.1	438.5	458.1	515.7	473.5	514.3

Table 2 continued. Water quality measurements at six stations on the mainstem of the middle Missouri River, 1978-79.

Water Quality Parameter	SAMPLING STATION Ulm Bridge	Morony Dam	Fort Benton	Coal Banks	Judith Landing	Robinson Bridge
	Near peak of spring runoff - June 15 & 19, 1979					
Total Hard. (mg/l)	155	198	176	204	199	208
Total Alk. (mg/l)	142	154	133	156	149	153
Turbidity (NTU)	20.0	23.0	1880	14.0	13.0	24.0
Na Adsorption Ratio	0.6	0.6	0.8	0.9	0.8	0.8
Tot. Susp. Sediment (mg/l)	40.8	40.8	2110	33.5	33.1	57.4
Cadmium, TR (mg/l Cd)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead, TR (mg/l Pb)	<0.005	<0.005	0.016	<0.005	<0.005	<0.005
Tot. Phosphorous (mg/l P)	0.060	0.060	1.5	0.050	0.050	0.070
Tot. Nitrogen, KJL (mg/l N)	0.33	0.82	4.60	0.60	0.45	0.51
Manganese, TR (mg/l Mn)	0.040	0.035	0.680	0.030	0.020	0.035
Aluminum, TR (mg/l Al)	0.70	0.60	4.3	0.30	0.30	0.40
Arsenic, TR (mg/l As)	0.014	0.010	0.009	0.009	0.009	0.008
Copper, TR (mg/l Cu)	<0.01	<0.01	0.030	<0.01	<0.01	<0.01
Zinc, TR (mg/l Zn)	<0.005	0.010	0.110	<0.005	<0.005	0.010
Iron, TR (mg/l Fe)	0.47	0.45	4.0	0.35	0.40	0.78
Tot. Ammonia (mg/l N)	0.03	0.26	0.15	0.25	0.02	0.08

Explanation: mg/l = milligrams per liter, meq/l = milliequivalents per liter, TR = total recoverable.

Inorganic nitrogen and phosphorous are generally recognized as having an influence on primary production in streams and lakes (Sawyer 1948, Chu 1942, Curry and Wilson 1955). Organic nitrogen, amino acids, and ammonia may inhibit biological growth whereas nitrates and phosphates stimulate phytoplankton (Chu 1942, Sawyer 1948). Nuisance growth of algae in flowing waters usually does not occur until total soluble inorganic nitrogen exceeds 0.35 mg/l and total phosphorous (as P) exceeds 0.05 mg/l. Both nitrogen and phosphorus must exceed these amounts for problems to develop. No clear conclusion can be made about the limiting nutrient for productivity in the middle Missouri River (Loren Bahls, Montana Department of Health and Environmental Sciences, personal communication).

During the winter of 1978-79, a major sewage pipeline break occurred on the Missouri River at Great Falls. It appears that the consequences of this break may be reflected to some extent in the relatively higher nitrogen concentration levels in early April and mid-June, 1979, at the five stations below Great Falls. However, the nitrogen concentrations were still generally below the maximum suggested permissible levels.

Even before the pipeline break, some nitrogen enrichment of the Missouri River was observed in the Great Falls area between Ulm and Morony Dam. A slight increase in nitrates, nitrites, and total nitrogen was evident in early August and mid-October, 1978, at the Morony Dam station immediately below Great Falls. However, the increase was not significant, and nitrogen levels were below the maximum suggested permissible levels.

Concentrations of trace elements and heavy metals (copper, lead, zinc, etc.) were within acceptable limits for all six stations. Concentrations of aluminum, zinc, and iron increased significantly following heavy rainstorms and during spring runoff, while the concentrations of other trace elements did not increase significantly.

FINDINGS - MACROINVERTEBRATES

Missouri River

Aquatic macroinvertebrate sampling was conducted at five study sites on the middle Missouri River from late October, 1976, through mid-September, 1977. The sites were located at Morony Dam, Fort Benton, Coal Banks Landing, Judith Landing, and Robinson Bridge. The Morony Dam, Fort Benton, and Coal Banks Landing sites were sampled on eight occasions at approximately six-week intervals. Because of channel ice, the Judith Landing and Robinson Bridge sites were sampled on seven and six occasions, respectively.

A total of 59,135 macroinvertebrates, representing 13 orders and at least 40 families, was collected during the study. The number of macroinvertebrates collected per kick sample ranged from 62 to 9,200 (Appendix Tables 18-22). Diptera, Ephemeroptera, Trichoptera and Plecoptera comprised 37, 32, 18, and 2 percent of the macroinvertebrates collected, respectively. (Table 3). The average number of subordinal taxa ranged from 18.4 at Robinson Bridge to 24.7 at Fort Benton.

Ephemeroptera (Mayflies)

The numerical percentage of mayflies, averaging all sampling dates, ranged from 19 percent at Fort Benton to 52 percent at Robinson Bridge (Table 3). Mayflies were the most common order at Judith Landing and Robinson Bridge. There were approximately twice as many mayflies at the Judith Landing and

Table 3. Percent composition (by order) and average number of subordinal taxa (in parentheses) of the aquatic macroinvertebrate community in the middle Missouri River, late October through mid-September 1976-77.

	Station					
Order	Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge	Combined Average
Plecoptera	<1 (0.2)	<1 (1.0)	1 (0.6)	4 (2.0)	4 (1.8)	2
Ephemeroptera	20 (2.5)	19 (4.4)	24 (4.3)	44 (6.1)	52 (6.5)	32
Trichoptera	24 (4.5)	31 (4.8)	8 (3.6)	18 (3.7)	9 (1.8)	18
Diptera	52 (9.8)	44 (10.2)	55 (8.5)	19 (7.6)	15 (4.5)	37
Others	4 (3.3)	6 (4.3)	12 (1.6)	15 (2.9)	20 (3.8)	11
Total Average No. of Subordinal Taxa	(20.3)	(24.7)	(18.6)	(22.3)	(18.4)	-

Robinson Bridge sites as there were at the upper three sampling sites. The lower two sampling sites, Judith Landing and Robinson Bridge, also exhibited the greatest mayfly diversity, with 9 and 11 genera, respectively (Table 4).

A total of 13 mayfly genera were collected in the study area. *Tricorythodes*, *Ephemerella*, *Rhithrogena*, *Stenonema*, *Heptagenia*, and *Baetis* were the most common and widely distributed genera. *Traverella* and *Ephoron* were not common in the kick samples; however, large numbers of these species were observed emerging from the river as adults during summer 1977 at the lower three sampling sites. Hornung and Pollard (1978) also found underrepresentation of *Traverella* in kick samples. They concluded that *Traverella* was not effectively sampled by the kick technique because of its close attachment to the substrate. *Ephoron*, a burrowing mayfly, is also difficult to dislodge from the substrate and collect in kick samples (Merritt and Cummins 1978). The occurrence of *Baetisca* at Coal Banks Landing was an anomaly, probably the result of drift from the Marias River where it is common.

Plecoptera (Stoneflies)

The numerical percentage of stoneflies, averaging all sampling dates, ranged from less than 1 percent at Morony Dam and Fort Benton to 4 percent at Judith Landing and Robinson Bridge (Table 3). Stoneflies were similar to mayflies in being significantly more abundant at Judith Landing and Robinson Bridge than the upper three sampling sites. The Judith Landing and Robinson Bridge sites also exhibited the greatest stonefly diversity with five and four genera, respectively (Table 4).

A total of five stonefly genera were collected in the study area. *Isoperla*, the most widely distributed genus, was common at all sites except Morony Dam. *Isogenus* was collected at all sites except Morony Dam; however, it was common only at Judith Landing. The remaining three stonefly genera were rare.

Trichoptera (Caddisflies)

The numerical percentage of caddisflies, averaging all sampling dates, ranged from 8 percent at Coal Banks Landing to 31 percent at Fort Benton (Table 3). Caddisflies were significantly more abundant at Morony Dam and Fort Benton than the lower three sampling sites. The Morony Dam site exhibited the greatest caddisfly diversity with eight genera (Table 4).

Nine caddisfly genera were collected in the study area. *Hydropsyche* was the most abundant and widely distributed genus, followed by *Cheumatopsyche*, *Brachycentrus*, and *Oecetis*. *Hydroptila* was sampled regularly from Morony Dam to Coal Banks Landing. *Leuchotrichia*, *Psychomyia*, and *Amiocentrus* were rare, found only at Morony Dam. The occurrence of *Heliopsyche* at Coal Banks Landing was an anomaly, probably the result of drift from the Marias River where it is common.

Diptera (Trueflies)

The numerical percentage of trueflies, averaging all sampling dates, ranged from 15 percent at Robinson Bridge to 55 percent at Coal Banks Landing (Table 3). Trueflies were numerically the most common order at Morony Dam, Fort Benton, and Coal Banks Landing. There was more than a twofold increase

Table 4. Longitudinal distribution, relative abundance and frequency of occurrence (in parentheses) of aquatic macroinvertebrates in the middle Missouri River, late October through mid-September 1976-77.

Taxa	Sampling Site				
	Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge
Ephemeroptera					
Baetiscidae					
Baetisca			R (13%)*		
Leptophlebiidae					
Leptophlebia			R (13%)	R (14%)	R (67%)
Paraleptophlebia		R (13%)			
Traverella			R (13%)	C (29%)	R (34%)
Emphemeridae					
Ephoron				R (29%)	R (17%)
Siphlonuridae					
Ametropus					R (34%)
Tricorythidae					
Tricorythodes	R (63%)	C (75%)	C (38%)	C (57%)	C (85%)
Caenidae					
Brachycercus					R (34%)
Ephemerillidae					
Ephemerella	R (13%)	C (63%)	C (38%)	C (71%)	C (50%)
Heptageniidae					
Rhithrogena	R (13%)	R (39%)	C (50%)	A (100%)	C (67%)
Stenonema	R (63%)	C (100%)	C (75%)	C (100%)	C (100%)
Heptagenia		R (39%)	C (87%)	C (100%)	A (100%)
Baetidae					
Baetis	A (100%)	A (100%)	A (100%)	C (100%)	C (85%)
Plecoptera					
Nemouridae					
Brachyptera			R (13%)		R (33%)
Capnia				R (29%)	R (17%)

Table 4 continued. Longitudinal distribution, relative abundance and frequency of occurrence (in parentheses) of aquatic, macroinvertebrates in the middle Missouri River, late October through mid-September 1976-77.

Taxa	Sampling Site				
	Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge
Perlidae					
Acroneuria	R (13%)	R (13%)		R (57%)	R (67%)
Perlodidae					
Isogenus		R (25%)	R (13%)	C (57%)	R (17%)
Isoperla		C (63%)	C (38%)	C (57%)	C (50%)
Trichoptera					
Hydroptilidae					
Hydroptila	C (75%)	A (100%)	C (50%)		
Leucotrichia	R (25%)				
Hydropsychidae					
Hydropsyche	A (100%)	A (100%)	C (100%)	C (86%)	C (50%)
Cheumatopsyche	C (75%)	A (100%)	C (88%)	C (100%)	C (67%)
Psychomyidae					
Psychomyia	R (13%)				
Leptoceridae					
Oecetis	C (88%)	C (75%)	C (63%)	C (88%)	R (17%)
Helicopsychidae					
Helicopsyche			R (13%)		
Brachycentridae					
Brachycentrus	R (38%)	C (88%)	C (38%)	A (100%)	C (50%)
Amiocentrus	R (38%)				
Diptera					
Tipulidae					
Tipula		R (25%)			
Hexatoma	R (15%)				
Simuliidae					
Simulium	R (25%)	R (50%)	R (25%)	R (29%)	R (33%)

Table 4 continued. Longitudinal distribution, relative abundance and frequency of occurrence (in parentheses) of aquatic, macroinvertebrates in the middle Missouri River, late October through mid-September 1976-77.

Taxa	Sampling Site				
	Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge
Empididae	R (50%)	R (50%)	R (25%)		R (17%)
Muscidae	R (15%)				
Chironomidae					
Tanypodinae					
Thienemannimyia gr.		C (100%)	C (75%)	C (75%)	R (75%)
Diamesinae					
Diamesa	R (25%)		R (25%)		
Monodiamesa	R (25%)	C (75%)	R (50%)	C (50%)	R (50%)
Potthastia	R (25%)				
Chironominae					
Chironomus	C (50%)	R (50%)	A (50%)	C (75%)	
Cryptochironomus		C (50%)	C (75%)	R (75%)	R (25%)
Demicryptochironomus		R (50%)		R (25%)	
Dicrotendipes	A (100%)	R (25%)	R (25%)		
Microtendipes	R (25%)	A (75%)	A (75%)	C (75%)	
Paracladopelma	R (25%)				
Phaenopsectra	A (100%)	A (100%)	C (50%)	R (75%)	
Polypedilum	A (75%)	A (100%)	A (100%)	C (75%)	R (75%)
Stenochironomus					R (50%)
Cladotanytarsus				R (25%)	
Micropsectra	R (25%)				R (25%)
Rheotanytarsus	C (100%)	R (50%)	C (75%)	R (50%)	R (50%)
Tanytarsus	C (50%)	R (25%)	R (25%)	R (50%)	
Orthocladiinae					
Cardiocladius	C (25%)				
Cricotopus	A (100%)	C (75%)	R (50%)	R (25%)	
Eukiefferiella	R (25%)	R (50%)		R (25%)	R (50%)
Orthocladius	A (100%)	R (50%)	C (100%)	R (25%)	

Table 4 continued. Longitudinal distribution, relative abundance and frequency of occurrence (in parentheses) of aquatic, macroinvertebrates in the middle Missouri River, late October through mid-September 1976-77.

Taxa	Sampling Site: Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge
Odonata					
Gomphidae					
Gomphus					R (16%)
Ophiogomphus	R (13%)	R (13%)	R (13%)		R (50%)
Heteroptera					
Corixidae					
Trichocorixa	R (13%)	R (25%)	R (13%)	C (43%)	R (50%)
Hesperocorixa		R (25%)		R (14%)	
Sigara	C (13%)	A (75%)	C (100%)	C (100%)	C (67%)
Coleoptera					
Gyrinidae					
Gyrinus			R (13%)		
Carabidae				R (14%)	
Dytiscidae					
Dytiscus		R (13%)			
Hydroporus		R (13%)	R (25%)		
Hydrovatus				R (14%)	R (33%)
Hydrophilidae					
Hydrophilus	R (13%)				R (33%)
Dryopidae					
Pelonomus		R (13%)			
Elmidae					
Dubiraphia		R (25%)		R (29%)	R (33%)
Ordobrevia		R (13%)	R (13%)	R (29%)	R (50%)
Stenelmis				R (29%)	R (33%)
Optioservus	R (13%)	R (25%)			
Lepidoptera					
Pyralidae					
Synclita			R (13%)		
Parargyractis	C (88%)	R (50%)			

Table 4 continued. Longitudinal distribution, relative abundance and frequency of occurrence (in parentheses) of aquatic, macroinvertebrates in the middle Missouri River, late October through mid-September 1976-77.

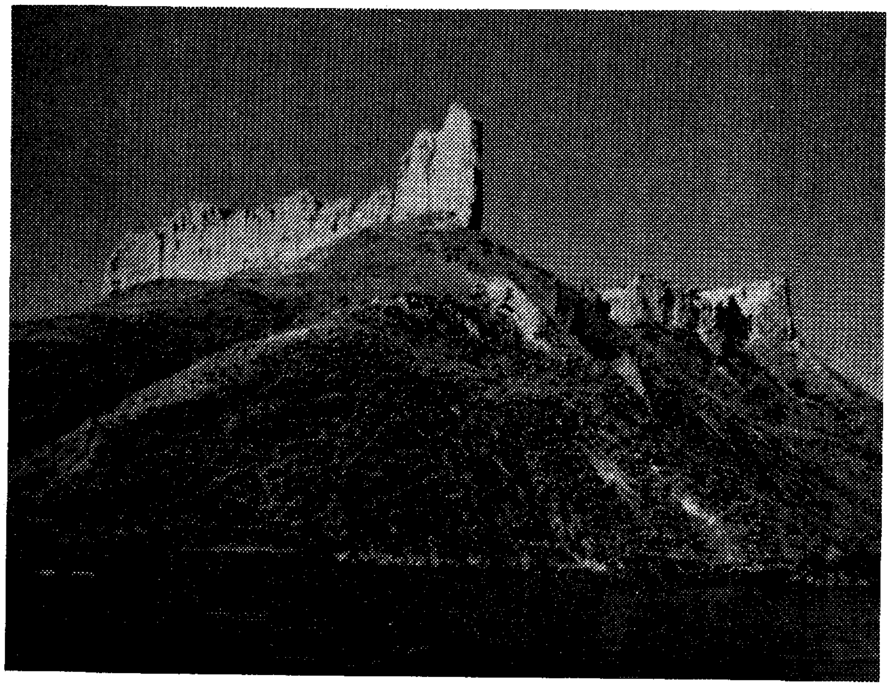
Taxa	Sampling Site				
	Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge
Nematomorpha	R (25%)	R (50%)			R (17%)
Pulmonata					
Ancylidae					
Ferrissia		R (63%)			
Physidae					
Physa			R (13%)		
Oligochaeta	C (88%)	A (100%)	C (75%)	C (57%)	C (100%)
Amphipoda					
Talitridae					
Hyalella	R (13%)				
Decapoda					
Astacidae					
Orconectes	R (50%)	R (13%)			

*Explanation: <u>Relative Abundance</u>

R = Rare - average less than 5 organisms per sample
C = Common - average 5 to 100 organisms per sample
A = Abundant - average more than 100 organisms per sample

<u>Frequency of Occurrence</u>

Percent of sample dates when organism was collected. For example, 25% frequency of occurrence = organism was collected on one-fourth of the sample dates at the sampling site.



in trueflies at these three sites compared to Judith Landing and Robinson Bridge. The Morony Dam site exhibited the greatest truefly diversity with 20 subordinal taxa (Table 4). Robinson Bridge exhibited the least diversity with 10 subordinal taxa. However, truefly diversity (particularly chironomid diversity) was probably underestimated at Robinson Bridge because of sampling problems.

Twenty-six subordinal taxa of trueflies were collected in the study area. *Chironomus, Microtendipes, Phaenopsectra, Polypedilum,* and *Rheotanytarsus* were the most common and widely distributed genera. *Potthastia, Paracladopelma, Micropsectra, Cardiocladius, Hexatoma* and Muscidae were collected only at Morony Dam. In contrast, *Thienemannimyia* gr. and *Cryptochironomus* were sampled regularly at all sites except Morony Dam.

Sixteen of the 21 subordinal taxa of trueflies collected in the study area were from the Chironomidae family. At Morony Dam, *Cricotopus, Orthocladius,* and to a lesser extent, *Phaenopsectra,* and *Dicrotendipes* were clearly the predominant chironomids. At Fort Benton, a notable change in chironomids occurred, and *Microtendipes, Phaenopsectra, Polypedilum,* and *Thienemannimyia* gr. were the most common taxa. This chironomid fauna essentially persisted throughout the lower three study sites. However, the attenuation of chironomids below Coal Banks Landing was apparent.

The chironomid fauna at the five sites sampled in this study is typical of large western Montana rivers on the east slope of the Continental Divide (Richard Oswald, Montana State University, personal communication). The change in the taxonomic composition of chironomids between Morony Dam and the four stations downstream is probably related to water temperature. Water temperature at Morony Dam from early June through early September, 1977, averaged 3 to 5 C degrees cooler than the downstream study sites. Several possible effects of the cooler water temperature at Morony Dam were observed:

(1) *Diamesa* were present in large numbers at Morony Dam in June and virtually absent from the downstream stations. *Diamesa* is a coldwater form which emerges in early spring from most streams.

(2) *Potthastia*, another coldwater form, was found only at the Morony Dam site.

(3) Orthocladiinae dominated over Chironominae during the cooler months at Morony Dam, while Chironominae dominated at the lower four study sites. Orthocladiinae typically dominate over Chironominae in cooler water and vice-versa in warmer water (Richard Oswald, Montana State University, personal communication).

(4) The two dominant Chironominae at Morony Dam, *Dicrotendipes* and *Phaenopsectra*, prefer cool water.

(5) *Polypedilum*, a warmwater form, was very common at the lower study sites throughout the spring and summer, but significant numbers were not observed at Morony Dam until August.

(6) The *Thienemannimyia* group, which prefers warmwater was totally absent from the Morony Dam site.

Other Macroinvertebrate Orders

The longitudinal distribution, relative abundance and frequency of occurrence for the remaining orders of macroinvertebrates sampled in the Missouri River are shown in Table 4. Two heteropterans (*Sigara* and *Trichocorixa*), a coleopteran family (Elmidae), and the order Oligochaeta were collected at all five sampling sites. The crayfish, *Orconectes*, was sampled regularly at Morony Dam and occasionally at Fort Benton.

Discussion

The structure of the aquatic macroinvertebrate community at Morony Dam was relatively simple compared to the four downstream study sites (Figure 8). Macroinvertebrate diversity increased progressively in a downstream direction. The Judith Landing and Robinson Bridge sites had the greatest diversity and the most "stable" community structure (Table 5).

A possible explanation for the community change between Morony Dam and the downstream sites is the apparent scarcity of good substrate for macroinvertebrate production at Morony Dam. At the Morony Dam sampling site, most of the substrate was comprised of flat rocks and bedrock. Hynes (1970) concluded that substrate is a major factor influencing distribution and abundance of aquatic macroinvertebrates.

The series of hydropower dams immediately upstream from the Morony Dam sampling site may also have an effect on the macroinvertebrate community. The dams may act as barriers to natural colonization (drift) of the macroinvertebrates.

Also, diurnal fluctuations of stage height in the river below the hydropower dams are more severe at the Morony Dam sampling site than at the downstream sites. This fluctuation could disrupt the macroinvertebrate

Table 5. A simplifed schematic assemblage of the most common aquatic macroinvertebrates sampled at five sites on the middle Missouri River, late October through mid-September 1976-77.

Order	Sampling Site: Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge
Mayfly	*Baetis*	*Tricorythodes* *Ephemerella* *Stenonema* *Baetis*	*Rhithrogena* *Stenonema* *Heptagenia* *Baetis*	*Tricorythodes* *Ephemerella* *Rhithrogena* *Stenonema* *Heptagenia* *Baetis*	*Tricorythodes* *Ephemerella* *Rhithrogena* *Stenonema* *Heptagenia* *Baetis*
Stonefly	----	*Isoperla*	*Isoperla*	*Acroneuria* *Isogenus* *Isoperla*	*Acroneuria* *Isoperla*
Truefly	*Chironomus* *Dicrotendipes* *Phaenopsectra* *Polypedilum* *Rheotanytarsus* *Tanytarsus* *Cricotopus* *Orthocladius*	*Thienemannimyia* *Monodiamesa* *Cryptochironomus* *Microtendipes* *Phaenopsectra* *Polypedilum* *Cricotopus*	*Thienemannimyia* *Chironomus* *Cryptochironomus* *Microtendipes* *Phaenopsectra* *Polypedilum* *Rheotanytarsus* *Orthocladius*	*Thienemannimyia* *Monodiamesa* *Chironomus* *Microtendipes* *Polypedilum*	*Thienemannimyia*
Caddisfly	*Hydroptila* *Hydropsyche* *Cheumatopsyche* *Oecetis*	*Hydroptila* *Hydropsyche* *Cheumatopsyche* *Oecetis* *Brachycentrus*	*Hydroptila* *Hydropsyche* *Cheumatopsyche* *Oecetis*	*Hydropsyche* *Cheumatopsyche* *Oecetis* *Brachycentrus*	*Hydropsyche* *Cheumatopsyche* *Brachycentrus*

Table 5 continued. A simplifed schematic assemblage of the most common aquatic macroinvertebrates sampled at five sites on the middle Missouri River, late October through mid-September 1976-77.

	Sampling Site				
Order	Morony Dam	Fort Benton	Coal Banks Landing	Judith Landing	Robinson Bridge
Others	Oligochaeta *Orconectes*	*Sigara* Oligochaeta	*Sigara* Oligochaeta	*Sigara* Oligochaeta	*Sigara* Oligochaeta

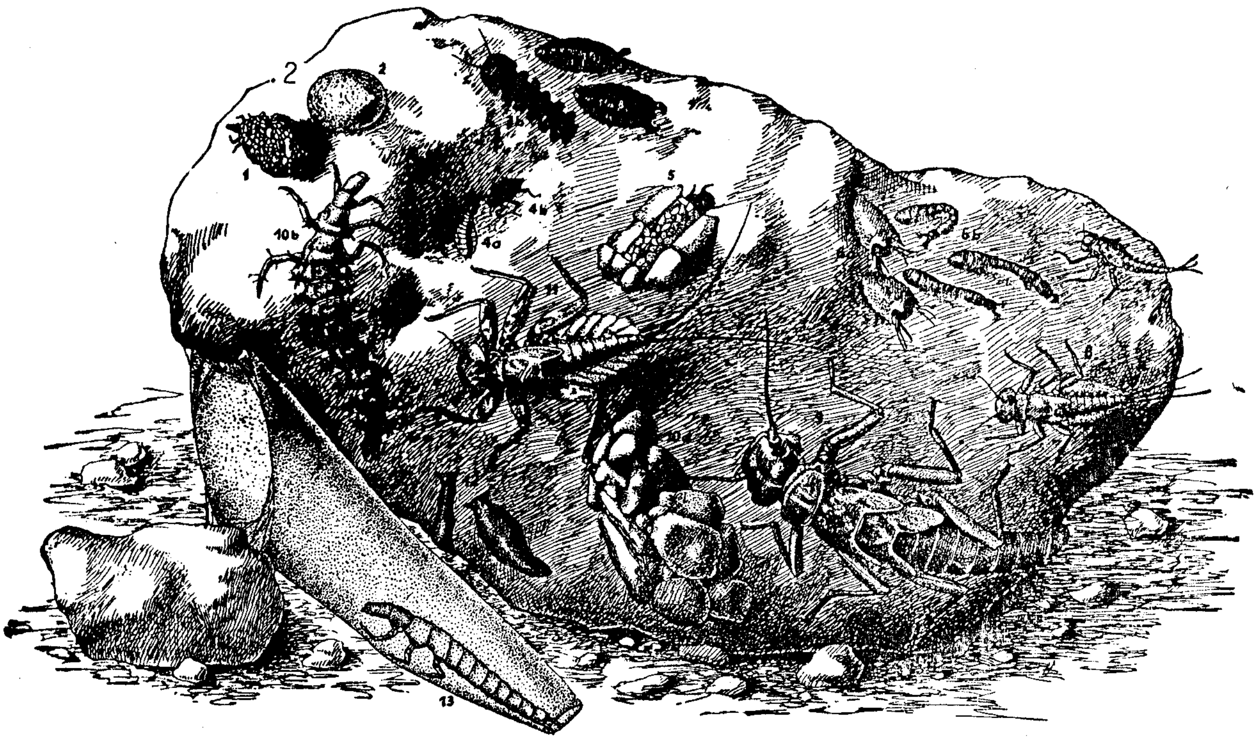


Figure 8. Diversity of the aquatic macroinvertebrate community was least at Morony Dam and greatest at Judith Landing and Robinson Bridge.

community.

Baetis, chironomids, and *Hydropsyche* were the predominant macroinvertebrate taxa collected at the Morony Dam site. As an average for all sampling dates combined, these taxa accounted for 83 percent of the macroinvertebrates collected at the Morony Dam site. In contrast, these taxa accounted for only 47 percent of the macroinvertebrates collected at the downstream sites. *Baetis*, chironomids, and *Hydropsyche*, because of their great variety of species, are generally considered very adaptable to wide changes in the normal physical and chemical conditions in a lotic system (Merritt and Cummins 1978). Stoneflies, which have a narrower environmental tolerance, were essentially absent from the Morony Dam site, and mayflies were found only in limited numbers. Although the aquatic macroinvertebrate community at the Morony Dam site was not as diverse as the downstream sites, the relative abundance of macroinvertebrates appeared to be similar to the downstream sites.

With a few important differences, the aquatic macroinvertebrate community of this Missouri River study area exhibited a striking resemblance to that of the Yellowstone River between Huntley and Glendive (Schwehr 1977). Considering the mayflies, stoneflies, and caddisflies only, both rivers contained a diverse mayfly taxa in contrast to a rather limited diversity of stonefly and caddisfly taxa. The mayfly diversity was slightly higher on the Yellowstone River, while stoneflies and caddisflies were slightly more diverse on the Missouri. Dominant subordinal taxa were essentially the same in both

rivers.

The largest number and greatest diversity of mayflies on the Yellowstone River occurred in the cold-water/warm-water transitional zone (Schwehr 1977). This was attributed to overlap of cold-water and warm-water forms. In contrast, the largest number and greatest diversity of mayflies on the middle Missouri River occurred downstream from the cold-water/warm-water transitional zone. Since the Yellowstone River exists in a natural free-flowing state, its macroinvertebrate community is probably a model for large rivers within its physiographic range. The flow regime of the middle Missouri River has been altered by upstream impoundments. This alteration has probably had some influence on the aquatic macroinvertebrate community of the river.

Marias and Judith Rivers

Aquatic macroinvertebrate sampling was conducted at study sites near the mouths of the Marias and Judith rivers in 1977 and 1978. The Marias River was sampled four times, and the Judith River was sampled three times (Appendix Table 23).

The lower Marias and Judith rivers had relatively diverse mayfly taxa, moderate caddisfly and truefly compositions, and a meager stonefly representation (Table 6). This composition is typical of western rivers. The mayfly, *Baetisca*, was sampled regularly in the lower Marias, but it was rare in the Missouri and apparently absent from the Judith River.

In general, the aquatic macroinvertebrate community of the Marias River is very similar to the Tongue River, a tributary of the Yellowstone River (Newell 1976). The Marias and Tongue rivers are both greatly influenced by large water impoundments. The truefly, *Atherix*, was sampled regularly in the Judith River but never in the Marias River. Similarly, Newell (1976) did not find *Atherix* in the Tongue River.

FINDINGS - LARVAL FISH

Larval fish were sampled at eight study sites on the mainstem of the Missouri River and at one study site on the lower Marias River near its mouth. Samples were collected from late May through late August, 1978, to determine timing and location of successful hatching and emergence of important fish species. The mainstem Missouri River sampling sites were located at Carter Ferry, Fort Benton, Coal Banks Landing, Little Sandy Creek, Judith Landing, Stafford Ferry, Cow Island, and Robinson Bridge (Figure 1).

A total of 6,141 larvae were collected in 53 samples from the Missouri River, and 966 larvae were taken in 11 samples from the Marias River (Appendix Table 24). The larval taxa sampled represented common adult fish known to occur in the study area.

Spatial Distribution

Missouri River

Catostominae (suckers) accounted for 86 percent of the fish larvae sampled at the mainstem Missouri River sites and were the predominant group sampled at all sites except Robinson Bridge (Table 7). The Ictiobinae/ Cyprinidae group (buffalo, carpsucker and minnows) was the only other major

Table 6. Taxonomic composition of the aquatic macroinvertebrate community in the lower Marias and Judith rivers, 1977-78. Asterisk (*) indicates the presence of a taxon at the sample site.

Taxa	Marias River	Judith River
Ephemeroptera		
Baetiscidae		
Baetisca	*	
Leptophlebiidae		
Leptophlebia		*
Traverella	*	*
Ephemeridae		
Ephemera	*	
Hexagenia	*	
Ephoron	*	
Siphlonuridae		
Isonychia	*	
Tricorythidae		
Tricorythodes	*	*
Ephemerellidae		
Ephemerella	*	*
Heptageniidae		
Rhithrogena	*	*
Stenonema	*	*
Heptagenia		*
Baetidae		
Baetis	*	*
Pseudocloeon	*	
Plecoptera		
Nemouridae		
Brachyptera		*
Perlidae		
Acroneuria	*	
Claassenia	*	
Perlodidae		
Isogenus	*	*
Isoperla	*	*
Trichoptera		
Hydroptilidae		
Hydroptila	*	*
Hydropsychidae		
Hydropsyche	*	*
Cheumatopsyche	*	*
Leptoceridae		
Oecetis	*	*
Helicopsychidae		
Helicopsyche	*	
Brachycentridae		
Brachycentrus	*	*
Diptera		
Tipulidae		
Hexatoma		*

Table 6 continued. Taxonomic composition of the aquatic macroinvertebrate community in the lower Marias and Judith Rivers, 1977-78. Asterisk (*) indicates the presence of a taxon at the sample site.

Taxa	Marias River	Judith River
Athericidae		
Atherix		*
Simuliidae		
Simulium	*	*
Empididae	*	*
Chironomidae		
Tanypodinae		
Thienemannimyia gr.		*
Diamesinae		
Monodiamesa	*	
Potthastia		*
Chironominae		
Microtendipes	*	*
Polypedilum	*	*
Rheotanytarsus		*
Orthocladiinae		
Cricotopus		*
Eukiefferiella		*
Orthocladius		*
Odonata		
Gomphidae		
Ophiogomphus	*	*
Heteroptera		
Corixidae		
Trichocorixa	*	
Sigara	*	
Coleoptera		
Hydrophilidae		*
Elmidae		
Microcylloepus	*	*
Ordobrevia	*	*
Pulmonata		
Physidae		
Physa	*	*
Oligochaeta	*	*

Table 7. Taxonomic composition and relative abundance (mean densities) of fish larvae sampled in the middle Missouri and lower Marias rivers, late May through mid-August 1978.

	Number of Larvae Sampled									
	Missouri River Sampling Site								Total	Total
Taxon	Carter Ferry	Fort Benton	Coal Banks	Little Sandy	Judith Landing	Stafford Ferry	Cow Island	Robinson Bridge	Missouri River	Marias River
Shovelnose sturgeon									0	2
Paddlefish			1	1					2	0
Goldeye					1	1	2		4	3
Catostominae	348	290	3755	137	46	391	154	39	5160	786
Ictiobinae/Cyprinidae	42	15	248	15	13	358	108	61	860	159
Channel catfish									0	4
Stonecat							1		1	0
Sauger			1			1			2	11
Sculpin									0	1
Total	390	305	4005	153	60	751	265	100	6029	966
Mean Density of Larvae*	28.4	35.6	306.8	7.4	5.1	27.4	14.6	12.9	-	105.9

*Explanation: Mean density is the number of fish larvae collected per 100 m^3 of river water filtered.

group collected. This group comprised a substantial portion of the larvae sampled at the lower three study sites. Ictiobinae/Cyprinidae accounted for 61 percent of the larvae sampled at Robinson Bridge.

Two paddlefish prolarvae (Figure 9) were collected in the Missouri River in 1978, one at Coal Banks Landing and one at Little Sandy Creek. The specimens were collected late at night, July 12, and the early morning, July 13 at each site, respectively. This finding confirms that paddlefish spawn successfully in the Missouri River at least as far upstream as Coal Banks Landing. Paddlefish larvae have also been sampled in the Yellowstone and Milk rivers, Montana (Russ Penkal and Kent Gilge, DFWP, personal communication).

Goldeye was a very common fish in the study area, but very few goldeye larvae were sampled, and those found were sampled only at the three lower study sites. The scarcity of goldeye is probably related to their preference for calm waters for spawning and incubation (Scott and Crossman 1973). Larval fish samples were collected in the Missouri River only at sites where current velocity was sufficient enough to stretch out the sampling net. Calm water, which probably was preferred by goldeye for spawning, was not sampled.

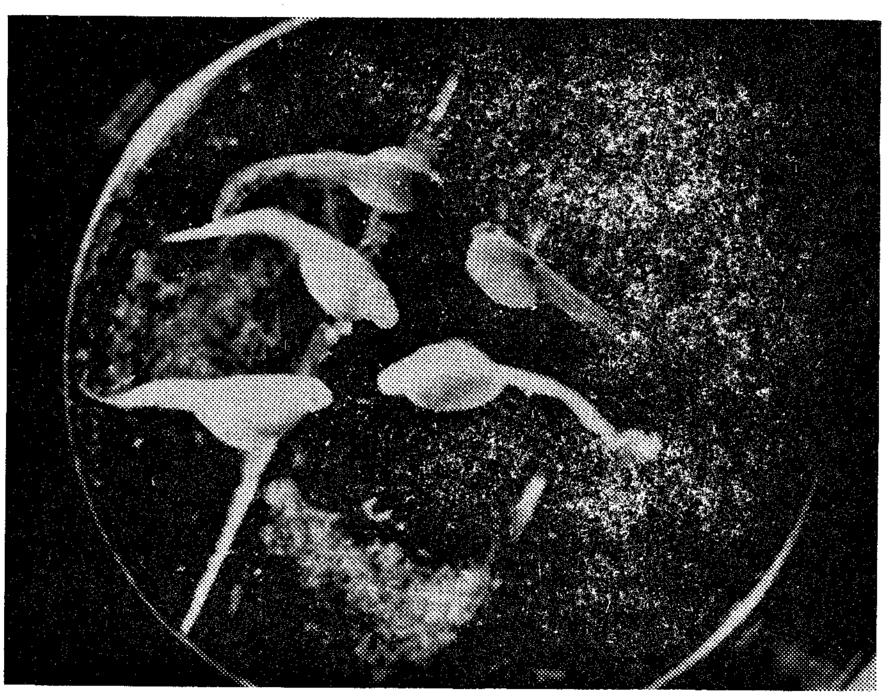


Figure 9. Paddlefish prolarvae were sampled on July 12-13, 1978, on the Missouri River at Coal Banks Landing and Little Sandy Creek.

The scarcity of sauger in the larval fish collections was probably related to time of sampling. Based on examination of the spawning condition of adult sauger, it is believed that the peak of spawning occurred in late April and early May, 1978. Assuming an incubation period of 13 to 21 days as described by Nelson (1968), most of the larval sauger probably emerged by the end of May. Intensive sampling for larval fish on the Missouri was not initiated until early June. Most larval sauger probably had emerged prior to this time. The two larval sauger which were collected on the Missouri River in 1978 were taken on June 13 and 15 at Coal Banks Landing and Stafford Ferry, respectively.

The greatest density of larval fish in 1978, for all sampling dates combined, was found at the Coal Banks Landing site. Mean density at this site was 306.8 larval fish/100 m^3 of water filtered (Table 7). Mean densities at the remaining seven sites ranged from 5.1 larvae/100 m^3 at Judith Landing to 35.6 larvae/100 m^3 at Fort Benton. Densities at the latter sites were similar to averages reported for the Missouri River below Gavins Point Dam in South Dakota (Kallemeyn and Novotny 1977).

Marias River

Taxonomic composition of larval fish in the Marias River in 1978 was similar to the Missouri River. Catostominae and Ictiobinae/Cyprinidae accounted for 81 and 17 percent, respectively, of the larvae sampled in the Marias (Table 7). The mean density of larval fish taken at the Marias River sampling site was 105.9 larvae/100 m^3.

Two shovelnose sturgeon prolarvae were collected in the Marias River on June 19, 1978. These were the first shovelnose sturgeon larvae ever collected in the Missouri River drainage above Fort Peck Dam, indicating that successful reproduction of shovelnose sturgeon occurs in the lower Marias River.

Very few goldeye larvae were sampled on the Marias River. The scarcity is probably related to sampling techniques previously described for goldeye in the Missouri River.

One channel catfish aelvin was sampled on the Marias River June 19, and three were collected July 28, 1978. This finding confirms that channel catfish spawn successfully in the lower Marias River.

Eleven sauger larvae were sampled on the lower Marias River June 1 and 2, 1978. Most larval sauger in the Marias River probably emerged prior to sampling.

Temporal Abundance

To facilitate interpretation of temporal abundance data for larval fish, the Missouri River was divided into three subreaches:

(1) Subreach 1 included the Carter Ferry and Fort Benton sampling sites,
(2) Subreach 2 included the Coal Banks Landing, Little Sandy Creek, and Judith Landing sampling sites, and
(3) Subreach 3 included the Stafford Ferry, Cow Island, and Robinson

Bridge sampling sites.

Two different peaks in temporal abundance of larval fish were observed in 1978. In Subreaches 1 and 2, peak densities were observed from late May through June, while in Subreach 3 the peak occurred in July (Figure 10). The relatively early peak densities of larval fish in the upper subreaches were related to the dominance of Catostominae (suckers) in the larval fish samples collected in the upper river. The later peak in Subreach 3 was due to the large number of Ictiobinae/Cyprinidae (buffalo, carpsuckers, and minnows) larvae which were sampled in the lower river. Brown (1971) indicated that Catostominae spawn earlier and prefer swifter water for spawning then Ictiobinae/Cyprinidae which prefer slow, protected water. The former habitat is common in Subreaches 1 and 2 while the latteris prevalent in Subreach 3.

The greatest density of larval fish on the Marias River in 1978 was observed in early June (Figure 10). However, the Marias was not sampled frequently enough to determine if this was the actual peak in abundance of larval fish.

FINDINGS - ADULT FISH POPULATIONS

Species Distribution, Relative Abundance and Size Composition

Fifty-three species representing 14 families of fish occur in the middle Missouri River drainage between Morony and Fort Peck dams (Table 8). Forty-two species are found in the mainstem of the Missouri River from Morony Dam to Fort Peck Reservoir. Known distribution of the remaining 11 species is limited to Fort Peck Reservoir or tributaries of the middle Missouri River. It is possible that some of the latter species occur as transients in the mainstem.

Longitudinal distribution of fish species sampled in the Missouri River during the inventory period, 1976 through 1979, is shown in Table 9. Sauger, burbot, white sucker, longnose sucker, shorthead redhorse, river carpsucker, carp, goldeye, freshwater drum, emerald shiner, western silvery minnow, and longnose dace were the most widely distributed fish species. They were abundant throughout the 333-km length of the study area. Northern pike and walleye were also distributed throughout the study area, but not as abundantly as the former species. Mountain whitefish, rainbow trout, brown trout, mountain suckers, and mottled sculpin were most common in the upstream study sections with only an occasional specimen found in the lower reaches. Shovelnose sturgeon, flathead chubs, blue suckers, smallmouth buffalo, bigmouth buffalo, and channel catfish were common in the Missouri River below the confluence of the Marias River but generally uncommon above the Marias. However, blue suckers and buffalo were common in the Missouri River upstream from the Marias River during their spawning period. Paddlefish were found seasonally in the Missouri River from Fort Peck Reservoir upstream to the confluence of the Marias River. They occurred primarily during April, May, and June when they migrated upstream from Fort Peck Reservoir into the Missouri River to spawn. Most paddlefish return to Fort Peck Reservoir following high water in June. It is not known if any paddlefish reside in the Missouri River throughout the year.

In 11 study sections on the middle Missouri River a total of 92,568 fish representing 41 species were sampled. The primary objective of the surveys was to determine species distribution, relative abundance, and size

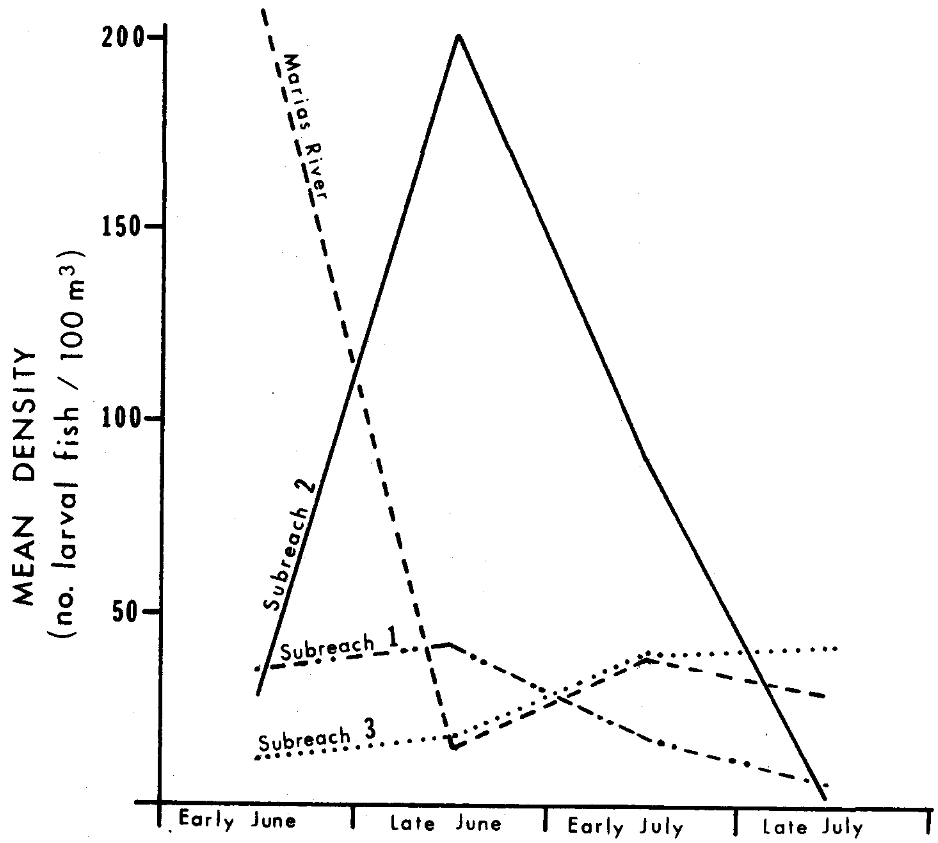


Figure 10. Temporal abundance of larval fish sampled in three subreaches of the Missouri River and at one site on the lower Marias River, early June through late July, 1978.

Table 8. Fish species recorded for the middle Missouri River drainage in Montana between Morony and Fort Peck Dams (family, scientific, and common names).

ACIPENSERIDAE (Sturgeon family)
Scaphirhynchus albus - Pallid sturgeon
Scaphirhynchus platorynchus - Shovelnose sturgeon

POLYODONTIDAE (Paddlefish family)
Polyodon spathula - Paddlefish

HIODONTIDAE (Mooneye family)
Hiodon alosoides - Goldeye

SALMONIDAE (Trout family)
Prosopium williamsoni - Mountain whitefish
Onocorhynchus kisutch - Coho salmon*
Onocorhynchus nerka - Kokanee*
Salmo clarkii - Cutthroat trout*
Salmo gairdneri - Rainbow trout
Salmo trutta - Brown trout
Salvelinus fontinalis - Brook trout
Salvelinus namaycush - Lake trout*

ESOCIDAE (Pike family)
Esox lucius - Northern pike

CYPRINIDAE (Minnow family)
Cyprinus carpio - Carp
Carassius auratus - Goldfish
Notemigonus crysoleucas - Golden shiner*
Phoxinus eos - Northern redbelly dace*
Phoxinus neogaeus - Finescale dace*
Hybopsis gracilis - Flathead chub
Hybopsis gelida - Sturgeon chub
Hybopsis meeki - Sicklefin chub
Couesius plumbeus - Lake chub
Notropis atherinoides - Emerald shiner
Hybognathus hankinsoni - Brassy minnow
Hybognathus placitus - Plains minnow
Hybognathus argyritis - Western silvery minnow
Pimephales promelas - Fathead minnow
Rhinichyths cataractae - Longnose dace

CATOSTOMIDAE (Sucker family)
Carpoides carpio - River carpsucker
Cycleptus elongatus - Blue sucker
Ictiobus bubalus - Smallmouth buffalo
Ictiobus cyprinellus - Bigmouth buffalo
Moxostoma macrolepidotum - Shorthead redhorse
Catostomus catostomus - Longnose sucker
Catostomus commersoni - White sucker
Catostomus platyrhynchus - Mountain sucker

Table 8 continued. Fish species recorded for the middle Missouri River drainage in Montana between Morony and Fort Peck Dams (family, scientific, and common names).

ICTALURIDAE (Catfish family)
Ictalurus melas - Black bullhead
Ictalurus punctatus - Channel catfish
Noturus flavus - Stonecat

GADIDAE (Codfish family)
Lota lota -Burbot

GASTEROSTEIDAE (Stickleback family)
Culaea inconstans - Brook stickleback*

CENTRARCHIDAE (Sunfish family)
Lepomis macrochirus - Bluegill*
Lepomis gibbosus - Pumpkinseed
Micropterus dolomieui - Smallmouth bass
Micropterus salmoides - Largemouth bass*
Pomoxis annularis - White crappie
Pomoxis nigromaculatus - Black crappie*

PERCIDAE (Perch family)
Perca flavescens - Yellow perch
Stizostedion canadense - Sauger
Stizostedion vitreum - Walleye
Etheostoma exile - Iowa darter

SCIAENIDAE (Drum family)
Aplodinotus grunniens - Freshwater drum

COTTIDAE (Sculpin family)
Cottus bairdi -Mottled sculpin

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*Known distribution is limited to Fort Peck Reservoir or tributaries to the middle Missouri River.

Table 9. Longitudinal distribution of fish species sampled in the middle Missouri River during the period from 1976 through 1979.

Fish Species	Morony Dam	Carter Ferry	Fort Benton	Loma Ferry	Coal Banks Landing	Hole-in-the-wall	Judith Landing	Stafford Ferry	Cow Island	Robinson Bridge	Turkey Joe
Pallid sturgeon					*				*	*	*
Shovelnose sturgeon		*	*	*	*	*	*	*	*	*	*
Paddlefish				*	*	*	*	*	*	*	*
Goldeye	*	*	*	*	*	*	*	*	*	*	*
Mountain whitefish	*	*	*	*	*				*		
Rainbow trout	*	*	*				*			*	
Brown trout	*	*	*	*							
Brook trout			*								
Northern pike	*	*	*	*	*		*			*	*
Carp	*	*	*	*	*	*	*	*	*	*	*
Flathead chub	*	*	*	*	*	*	*	*	*	*	*
Sturgeon chub							*		*	*	
Sicklefin chub									*	*	*
Lake chub	*	*	*	*	*	*	*				
Emerald shiner	*	*	*	*	*	*	*	*	*	*	*
Brassy minnow											*
Plains minnow	*	*		*					*	*	
Western silvery minnow	*	*	*	*	*	*	*	*	*	*	*
Fathead minnow	*	*	*	*	*	*	*		*	*	
Longnose dace	*	*	*	*	*	*	*	*	*	*	*
River carpsucker	*	*	*	*	*	*	*	*	*	*	*
Blue sucker	*	*	*	*	*	*	*	*	*	*	*
Smallmouth buffalo	*	*	*	*	*	*	*	*	*	*	*
Bigmouth buffalo	*	*	*	*	*	*	*	*	*	*	*

Table 9 continued. Longitudinal distribution of fish species sampled in the middle Missouri River during the period from 1976 through 1979.

Fish Species	Morony Dam	Carter Ferry	Fort Benton	Loma Ferry	Coal Banks Landing	Hole-in-the-wall	Judith Landing	Stafford Ferry	Cow Island	Robinson Bridge	Turkey Joe
Shorthead redhorse	*	*	*	*	*	*	*	*	*	*	*
Longnose sucker	*	*	*	*	*	*	*	*	*	*	*
White sucker	*	*	*	*	*	*	*	*		*	
Mountain sucker	*	*	*	*	*						
Black bullhead				*							
Channel catfish			*	*	*	*	*	*	*	*	*
Stonecat		*	*	*	*	*	*	*	*		
Burbot	*	*	*	*	*	*	*	*	*	*	*
Pumpkinseed				*							
Smallmouth bass					*						
White crappie					*		*			*	*
Yellow perch		*	*	*	*		*		*	*	*
Sauger	*	*	*	*	*	*	*	*	*	*	*
Walleye	*	*	*	*	*	*	*		*	*	
Iowa darter		*	*								
Freshwater drum	*	*	*	*	*	*	*		*	*	*
Mottled sculpin	*	*	*	*	*	*	*			*	
Total number of species	26	30	31	32	31	24	29	19	27	30	24

composition. The study sections were located near Morony Dam, Carter Ferry, Fort Benton, Loma Ferry, Coal Banks Landing, Hole-in-the-Wall, Judith Landing, Stafford Ferry, Cow Island, Robinson Bridge, and Turkey Joe (Figure 1). Exact descriptions of the study section boundaries are given in Appendix Table 25.

Catch rate summaries for electrofishing and gill net surveys are presented in Tables 10 and 11, respectively. The catch rate summaries provide an indication of species composition in each study section and allow for a general comparison of relative abundance of fish populations between study sections. Total catch, average size, and size range for individual species sampled in each study section by electrofishing and gill netting are shown in Appendix Tables 26 through 46.

Electrofishing surveys indicated that sauger was the most common game fish species in the Missouri River. The greatest densities of sauger were found in the Missouri River above the confluence of the Marias River. During the four-year inventory, an average of 11.0 sauger per electrofishing hour were sampled in the Missouri River above the Marias, and 2.1 sauger per hour were collected below the Marias (Table 10). In the Morony Dam section, the uppermost study area, an average of 20.1 sauger per electrofishing hour were sampled. This was more than twice the catch rate observed for sauger in any of the remaining 10 study sections.

Shovelnose sturgeon and burbot were also common game fish, averaging 1.2 and 0.2 fish per electrofishing hour, respectively, for the 11 study sections. Walleye, northern pike, channel catfish, and the four salmonid species found in the Missouri River all averaged 0.1 or fewer fish per electrofishing hour. Northern pike, burbot, and channel catfish do not respond as well to electrofishing as the other game fish species. Therefore, densities indicated for these species in the electrofishing surveys are an underestimate of their actual relative abundance and cannot be used for comparison.

Excluding forage species (minnows, dace, sculpin, etc.), goldeye, shorthead redhorse, and longnose suckers were the most common nongame species. For the 11 study sections combined, an average of 18.8 goldeye, 9.2 shorthead redhorse, and 6.2 longnose suckers per electrofishing hour were sampled. Carp, river carpsucker, blue sucker, smallmouth buffalo, freshwater drum, and white sucker averaged 3.1, 1.2, 0.8, 0.5, 0.4, and 0.4 fish per electrofishing hour, respectively. The remaining nongame fish species all averaged 0.1 or fewer fish per electrofishing hour.

Channel catfish are a common and important game fish in the Missouri River. However, they respond poorly to many kinds of sampling techniques. Boom shocking, gill netting, frame trapping, and seining all failed to produce a sufficient sample of channel catfish. Other researchers have also reported problems sampling channel catfish in main channel areas of large rivers (Haddix and Estes 1976, Schmulbach 1974). However, good success has been reported by researchers in the states of Missouri (Ragland and Robinson 1972) and Iowa (Helms 1973) sampling for channel catfish in large rivers with baited hoop nets.

Channel catfish were sampled with baited hoop nets at six sites in the study area during the four-year inventory period. Four of the study sites were located on the mainstem of the Missouri at Turkey Joe, Two Calf Island, Judith Landing, and Loma Ferry. These study sites are 3, 45, 136, and 248

Table 10. Catch rate summary for electrofishing surveys conducted on the middle Missouri River from 1976 through 1979, expressed as number of fish sampled per electrofishing hour.

Fish species	Morony Dam	Carter Ferry	Fort Benton	Loma Ferry	Coal Banks Landing	Hole-in-the-wall	Judith Landing	Stafford Ferry	Cow Island	Robinson Bridge	Turkey Joe
Pallid sturgeon					tr1/				0.1		
Shovelnose sturgeon		0.1	0.4	1.9	2.3	1.4	1.2	0.8	2.0	1.8	0.3
Goldeye	22.7	41.7	13.2	24.9	29.3	14.0	13.9	5.5	11.6	19.5	10.3
Mountain whitefish	1.0	0.2	1.2	0.4	0.1				tr		
Rainbow trout	0.5	tr	tr				tr				
Brown trout	0.5	0.2	0.1	tr							
Brook trout			tr								
Northern pike	tr	tr		tr	tr		tr				0.3
Carp	1.5	0.7	3.7	3.7	6.5	0.6	3.2	1.9	6.3	2.2	4.1
Flathead chub	tr	tr	0.4	1.7	0.7	0.3	0.8	0.3	0.5	0.9	
Emerald shiner	0.2	0.1	0.1	0.3	tr		0.1			0.5	
Western silvery minnow	4.7	0.2	0.1	tr	0.1		0.2		tr	0.7	0.3
Longnose dace	0.3	0.2	0.1	tr							
River carpsucker	0.3	0.7	0.9	2.9	2.2	0.6	3.0	0.5	1.2	0.9	0.8
Blue sucker	0.1	0.4	0.3	1.1	0.9	0.9	1.0	1.7	1.3	0.6	
Smallmouth buffalo	0.9	0.7	0.6	1.3	0.9	0.2	0.4	0.1	0.5	0.1	
Bigmouth buffalo	0.1	tr	0.2	0.3	0.2	0.1	0.2	0.1	tr	tr	
Shorthead redhorse	7.3	14.5	22.0	15.2	21.4	2.3	16.5	3.4	3.4	2.1	
Longnose sucker	17.9	16.2	11.9	14.7	8.0	0.9	4.3	0.6	0.1	0.1	
White sucker	1.8	0.2	1.0	0.4	0.3		0.5		0.1		
Mountain sucker	0.6	tr	0.1	tr	tr						
Channel catfish					tr		0.2		tr	tr	
Stonecat			0.1		tr		tr				
Burbot	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.1	tr	0.1	1.0
White crappie						0.1				tr	
Yellow perch		tr		0.1							

Table 10 continued. Catch rate summary for electrofishing surveys conducted on the middle Missouri River from 1976 through 1979, expressed as number of fish sampled per electrofishing hour.

Fish Species	Morony Dam	Carter Ferry	Fort Benton	Loma Ferry	Coal Banks Landing	Hole-in-the-wall	Judith Landing	Stafford Ferry	Cow Island	Robinson Bridge	Turkey Joe
Sauger	20.1	6.1	6.7	4.8	3.6	0.6	3.6	0.7	0.9	2.9	7.9
Walleye	0.3	tr	0.1	0.2	tr		tr			tr	
Freshwater drum	2.6	0.6	0.3	0.5	0.2	tr	0.2		0.1	0.1	
Mottled sculpin	0.5	0.1	0.1	tr	tr	tr	tr				
Total	84.2	83.1	63.7	74.7	76.8	22.1	49.8	15.7	28.2	32.6	25.0

1/ tr - trace (less than 0.05 fish per electrofishing hour)

Table 11. Catch rate summary for experimental gill net surveys conducted on the middle Missouri River in 1976 and 1977, expressed as number of fish captured per overnight net set.

Fish Species	Morony Dam (0)1/	Carter Ferry (4)	Fort Benton (12)	Loma Ferry (11)	Coal Banks Landing (9)	Hole-in-the-Wall (4)	Judith Landing (9)	Stafford Ferry (4)	Cow Island (4)	Robinson Bridge (5)	Turkey Joe (24)
Shovelnose sturgeon	Morony Dam study section - not sampled with gill nets.		0.25	4.27	0.56		0.22				
Goldeye		0.25	8.00	33.90	9.78	3.75	2.89		1.75	58.80	11.46
Mountain whitefish				0.09							
Rainbow trout										0.20	
Brown trout			0.08								
Northen pike		0.50		0.09						0.60	0.04
Carp			1.42	0.73	0.11		0.56			0.60	0.42
Flathead chub			0.42	0.36	0.11		0.22			0.40	
River carpsucker			0.50	1.73	0.11					5.40	1.25
Blue sucker			0.42								
Smallmouth buffalo			0.17	0.18							0.42
Bigmouth buffalo			0.33								
Shorthead redhorse		0.50	2.00	3.82	2.22	1.00	0.55	0.50		0.20	0.42
Longnose sucker		0.75	3.50	2.10	0.66		1.22				
White sucker		0.50	0.83	0.09	0.55		0.11			0.20	
Mountain sucker			0.25								
Black bullhead				0.18							
Channel catfish							0.11			0.20	0.13
Stonecat			0.17	0.09	0.11			0.25			
Burbot			0.17	0.09		0.25	0.11				
White crappie					0.25		0.44			0.20	0.25
Yellow perch				0.09	0.25		0.11			0.20	
Sauger		2.25	1.92	1.55	7.22	1.00	3.67	0.50	3.75	17.80	7.58
Walleye			0.13	0.09	0.22					0.60	
Freshwater drum			1.13	0.18							0.17
TOTAL	-	4.75	21.69	49.63	22.15	6.00	10.21	1.25	5.50	85.40	22.14

1/ Number of net sets in study section.

km upstream from Fort Peck Reservoir, respectively. The remaining two study sites were located on the Marias River 1 to 10 km upstream from the mouth and on the Teton River 1 to 2 km upstream from the mouth. Sampling for channel catfish with baited hoop nets was conducted during the months of June through September.

A total of 2,049 channel catfish and 119 fish of other species were captured in 313 net-days at the six study sites. A net-day represents one baited hoop net fished for a 24-hour period. Catch rates for channel catfish were consistently higher at the Turkey Joe study site than at the other sampling sites. The catch rate at Turkey Joe averaged 10.0 channel catfish per net-day (Table 12). Catch rates at the Two Calf Island, Judith Landing, Loma Ferry, Marias River, and Teton River study sites averaged 3.0, 1.1, 0.2, 0.8 and 1.0 channel catfish per net-day, respectively.

The catch data can be used to make a general comparison of relative abundance of channel catfish between study sites. However, since the baited hoop nets are selective for channel catfish, the catch rates cannot be used to determine relative abundance of other species. Total catch, average size, and size range of channel catfish and other species sampled in hoop nets at the six study sites during the inventory period are shown in Appendix Tables 47 through 52.

The average size (mean total length) of a number of fish species was larger in the upper study sections than in the lower sections (Figure 11). This phenomenon can be explained largely by the upstream migration of mature adults before or after spawning, and the downstream drift of emergent larval fish into the lower study sections following spawning. Gardner and Berg (1981) found the most important rearing areas for several fish species in the Missouri River in this study area were in downstream sites. The larger number of subadult fish rearing in the downstream study sites accounts for the smaller average size of fish in these areas. Graham and Penkal (1978) observed that sauger in the upper section of the lower Yellowstone River had a larger average length than those in the lower section. They attributed this to a general upstream migration of mature sauger after spawning.

Spawning Migrations, Spawning Periods & Fish Movements

Paddlefish Spawning Migrations

Paddlefish are native to Montana and are found in both the Yellowstone and Missouri River drainages. Significant numbers of paddlefish are found seasonally in the lower Yellowstone River and in the Missouri River in the dredge cut complex below Fort Peck Dam. Another paddlefish population inhabits Fort Peck Reservoir. A portion of this population seasonally migrates upstream from Fort Peck Reservoir into the present study area to spawn.

The paddlefish was formerly abundant throughout much of the Mississippi/Missouri River System but has undergone a drastic decline since 1900 (Pflieger 1975, Rehwinkel 1975, Vasetskiy 1971). A combination of destructive influences, including overharvest and loss of habitat in some areas, has contributed to this decline. Only six major, self-sustaining populations of paddlefish remain in the United States today, including the population in this study area (Berg 1980).

The annual migration of paddlefish from Fort Peck Reservoir into the Missouri River was studied during 1977, 1978, and 1979. The main objectives

Table 12. Catch rate summary for baited hoop net surveys conducted on the middle Missouri River from 1977 through 1979, expressed as number of fish captured per net-day.

	STUDY SITE					
Fish Species	Turkey Joe (196)1/	Two Calf Island (2)	Judith Landing (28)	Loma Ferry (33)	Marias River (34)	Teton River (20)
Channel catfish	10.0	3.0	1.1	0.2	0.8	1.0
Shovelnose sturgeon			tr		0.4	
Sauger	0.1		0.1	0.1	0.2	0.3
Northern pike					tr	
Burbot	tr2/				0.1	
Goldeye	tr		tr		0.1	0.1
Carp	tr			tr		
Freshwater drum	tr					
Smallmouth buffalo	tr					
Shorthead redhorse	tr		tr	0.2	0.1	0.1
Longnose sucker				0.1	0.1	
White sucker					0.2	
River carp-sucker	tr				0.1	0.3
Flathead chub						0.1
Total	10.2	3.0	1.3	0.6	2.1	1.7

1/ Number of net-days sampled at the study site.
2/ tr - trace (less than 0.05 fish/net-day).

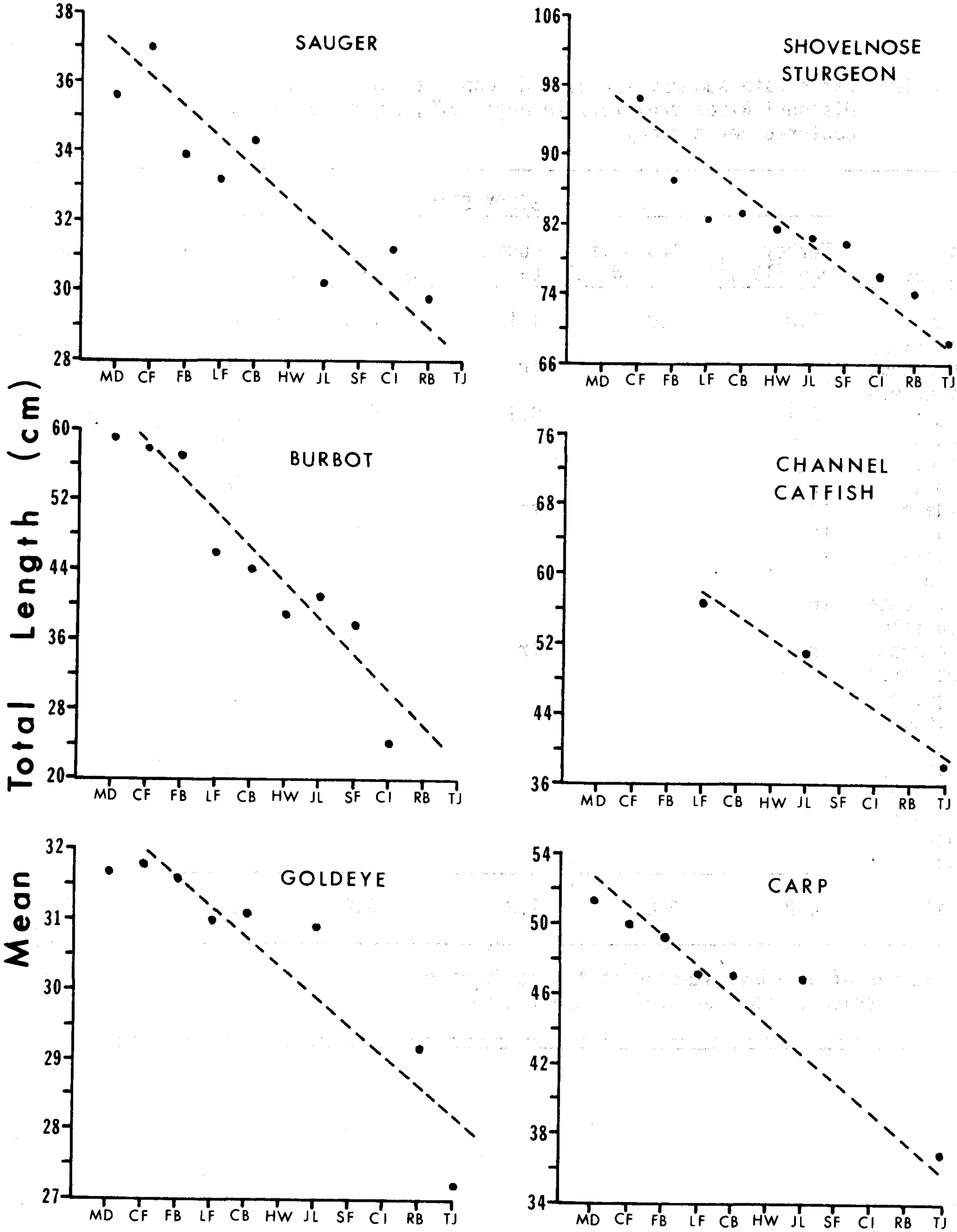


Figure 11. Decrease in average size (mean total length) of six fish species at downstream study sites on the middle Missouri River. Study section abbreviations are: MD = Morony Dam, CF = Carter Ferry, FB = Fort Benton, LF = Loma Ferry, CB = Coal Banks Landing, HW = Hole-in-the-Wall, JL = Judith Landing, SF = Stafford Ferry, CI = Cow Island, RB = Robinson Bridge, and TJ = Turkey Joe.

were to monitor the migration to determine timing of the run, relative abundance of paddlefish involved in the run, and extent of their upstream movements.

The migration was monitored by sampling with boom suspended electrofishing apparatus. Survey counts were made by tabulating all paddlefish observed by the boat operator and dip netter during the electrofishing operation (Figures 12 and 13). Since the effective field of the boom shocker did not cover the entire width of the river, the survey counts are a sample of the spawning run, not a complete census.

A direct current of 6 to 8 amps and 120 volts pulsed at 120 to 160 pulses per second with a pulse width of 40 to 50 percent was sufficient to make the survey counts. The effective field of the boom shocker at this setting was 15 to 20 meters. More than a thousand paddlefish were counted in three years with the electrical field at this setting, and no paddlefish mortality was observed. Paddlefish were considerably less vulnerable to electrofishing mortality at these settings than other game fish species such as sauger, walleye, mountain whitefish, and trout. Only two known paddlefish electrofishing mortalities occurred during the entire three years, and these occurred at the inception of the study when the current was allowed to exceed 10 amps and 200 volts. The electrofishing census technique was a very safe and effective method for monitoring the paddlefish migration in the Missouri River.

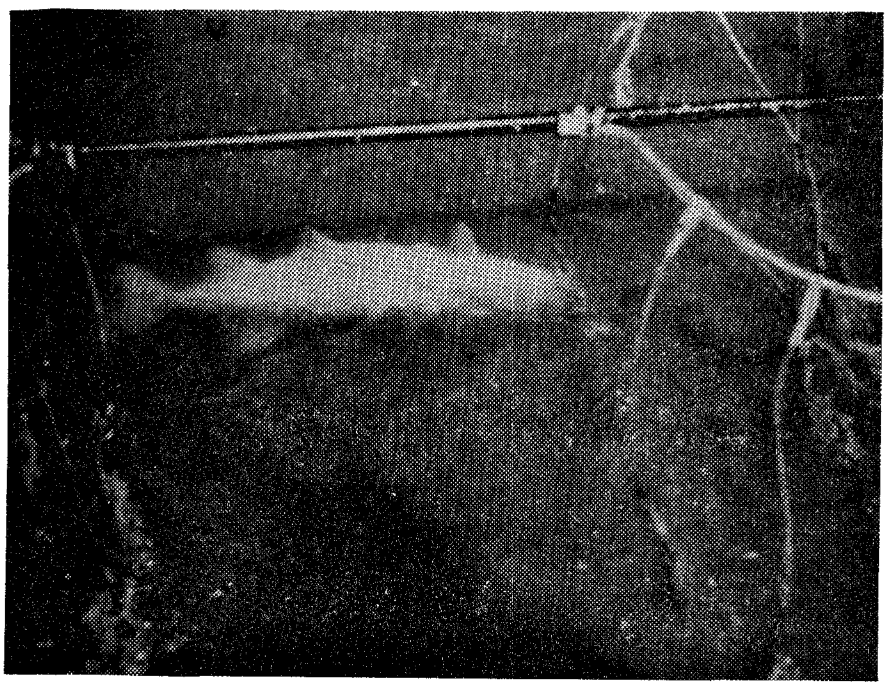


Figure 12. Photograph of a paddlefish in the field of the positive electrodes ahead of the boat.

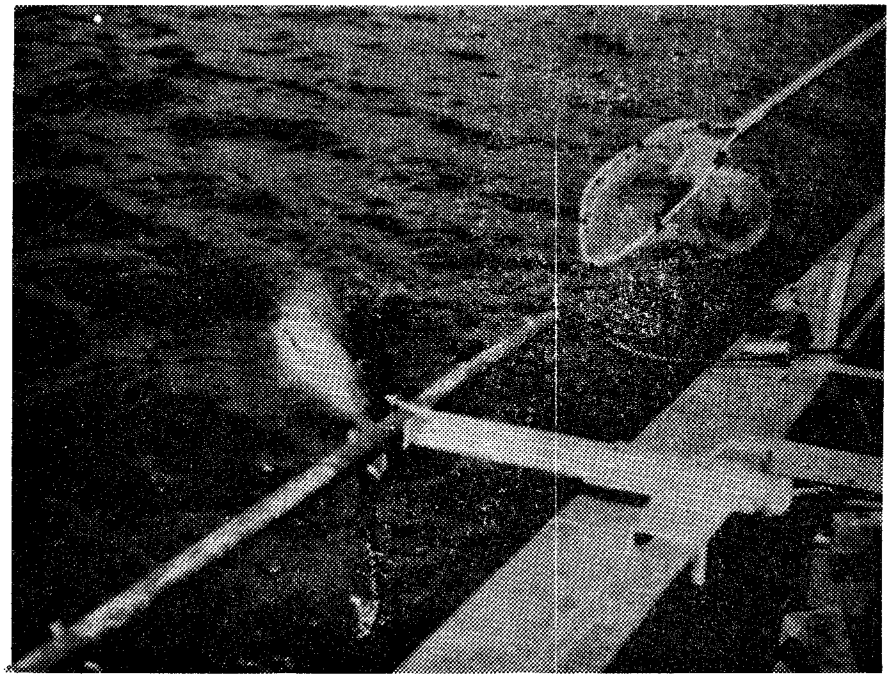


Figure 13. Photograph of a paddlefish in the field of the negative electrode at the side of the boat.

Twelve electrofishing survey runs were made during a 119-day period from April 6 to August 2, 1977 (Table 13). The most paddlefish observed in a survey run was 63 on May 19. Nearly all paddlefish counted during the 1977 migration period were observed in the lower 37 km of the Missouri River between Robinson Bridge and Fort Peck Reservoir (Figure 14). The farthest documented upstream movement was one paddlefish observed 42 km upstream from Fort Peck Reservoir on June 18.

Flow was well below normal in the Missouri River during the 1977 migration period. Peak flow was about 221 m^3/sec (7800 cfs) from early to mid-May at the Virgelle gage station. Because of the low flows, the paddlefish migration was severely reduced. A relatively small number of fish was involved in the run, and the extent of their upstream movements was minimal. Some paddlefish remained in the lower 37 km of the Missouri River during July, August, and September (Figure 15). These fish were probably waiting for sufficient flow to make an extended migration, but this flow was not achieved in 1977. Since there is no known suitable spawning substrate in the lower 37 km of the river, it is likely that spawning success in 1977 was very poor.

Table 13. Number of paddlefish counted in electrofishing survey runs on the middle Missouri River in 1977.

River Section	Census Dates, 1977											
	4/06	4/07	4/14	4/19	4/21	5/02	5/05	5/19	6/02-6/03	6/14-6/18	6/29-7/08	7/18-8/02
Marias River (245.2)1/ to Coal Banks Landing (212.5)										0	0	0
Coal Banks Landing (212.5) to Hole-in-the-Wall (177.0)										0	0	0
Hole-in-the-Wall (177.0) to Judith Landing (135.6)										0	0	0
Judith Landing (135.6) to Stafford Ferry (113.9)									0	0	0	0
Stafford Ferry (113.9) to Bird Rapids (92.0)									0	0	0	0
Bird Rapids (92.0) to Cow Island (70.2)									0	0	0	0
Cow Island (70.2) to Grand Island (50.5)									0	0	0	0
Grand Island (50.5) to Robinson Bridge (37.3)						0	0	0	0	3	0	0
Robinson Bridge (37.3) to Slippery Ann (27.7)	0		0	0	2	3	5	7	2	3		
Slippery Ann (27.7) to Rock Creek (16.3)	0	0	0	1	7	8	11	12	12	8		
Rock Creek (16.3) to Ft. Peck Reservoir	0	0	3	9	12	30	36	44	24	19		
Total	0	0	3	10	21	41	52	63	38	33	0	0

1/ River kilometers upstream from Fort Peck Reservoir.

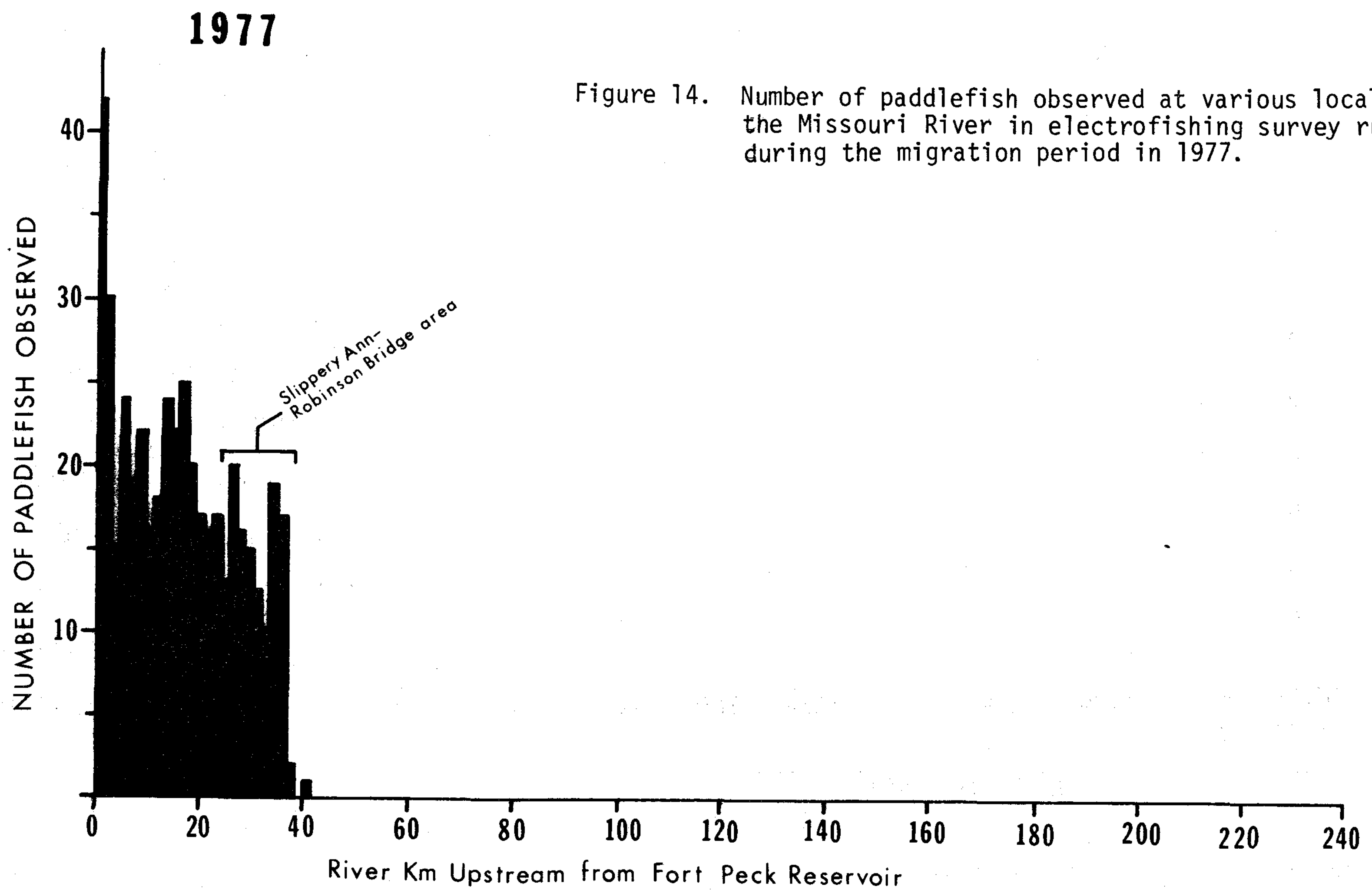
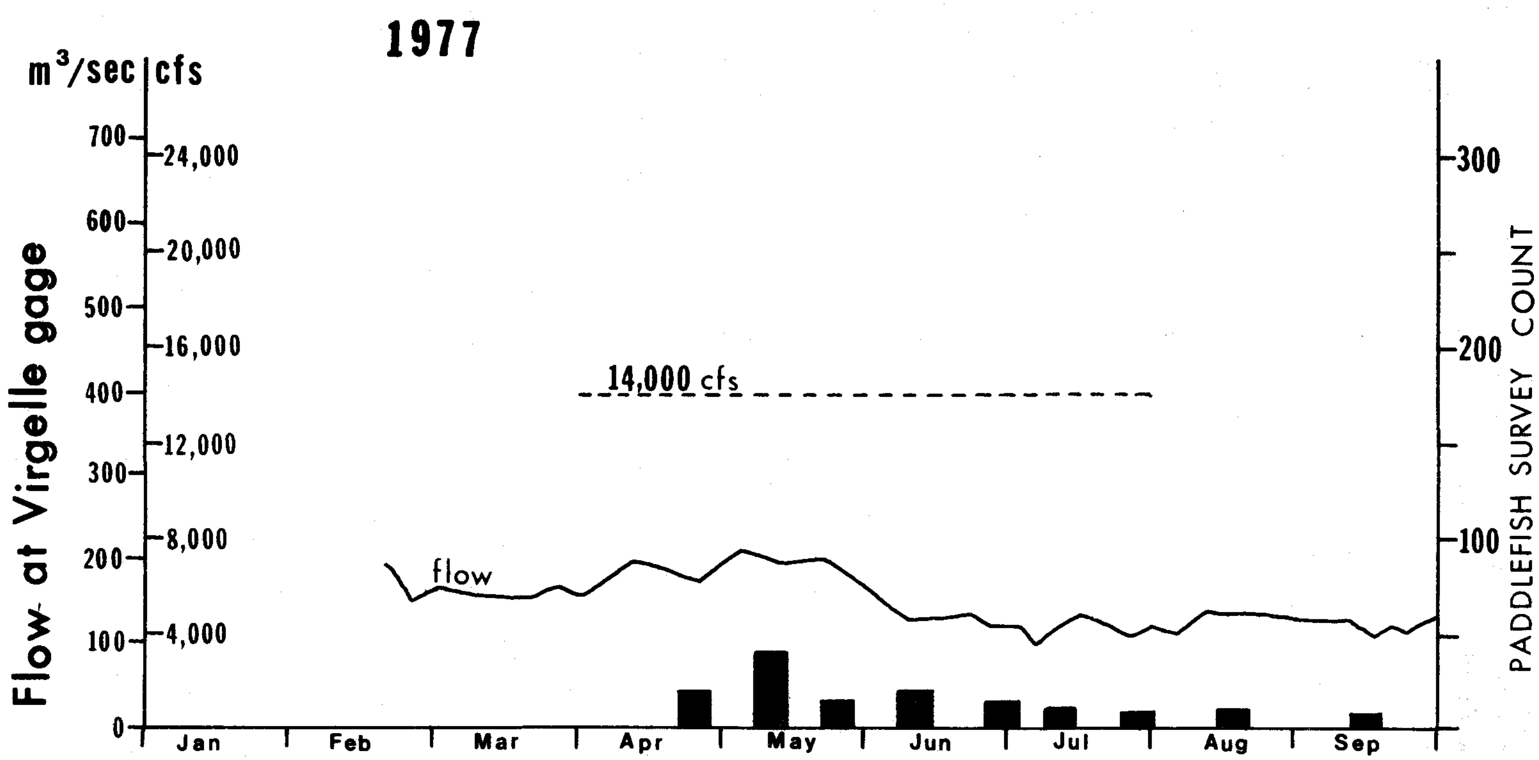


Figure 14. Number of paddlefish observed at various localities along the Missouri River in electrofishing survey runs made during the migration period in 1977.

Figure 15. Relationship between the total number of paddlefish counted in electrofishing surveys and discharge of the Missouri River at Virgelle in 1977.



In 1978, flow in the Missouri River was about normal during the migration period, and a substantial number of paddlefish were found upstream from Robinson Bridge (Table 14). Six electrofishing survey runs were made during a 128-day period from April 26 through August 21. The most paddlefish observed was 244 in a survey run from May 10 through 14. The farthest documented upstream movement was two paddlefish observed 241 km upstream from Fort Peck Reservoir (about 3 km below the mouth of the Marias River) on June 13, 1978.

Table 14. Number of paddlefish counted in electrofishing survey runs on the middle Missouri River in 1978.

	Census Dates, 1978					
River Section	4/26-4/27	5/10-5/14	5/23-5/26	6/13-6/16	7/19-7/25	8/14-8/21
Highwood Creek (320.1)[1/]						
to					0	0
Carter Ferry (306.8)						
to					0	0
Fort Benton (281.1)						
to				0	0	0
Marias River (245.2)						
to			10	8	4	0
Coal Banks Landing (212.5)						
to		3	7	7	2	0
Hole-in-the-Wall (177.0)						
to		7	0	4	1	0
Judith Landing (135.6)						
to		8	1	2	1	0
Stafford Ferry (113.9)						
to		4	8	12	1	0
Bird Rapids (92.0)						
to		16	7	9	0	0
Cow Island (70.2)						
to	7	127	40	56	3	0
Grand Island (50.5)						
to	26	31	10	15	1	0
Robinson Bridge (37.3)						
to	30	32	15	17	2	
Slippery Ann (27.7)						
to	6	5	6	4	1	
Rock Creek (16.3)						
to	22	11	3	4	2	
Fort Peck Reservoir (0.0)						
Total	91	244	107	138	18	0

1/ River kilometers upstream from Fort Peck Reservoir.

A significant migration did not develop in 1978 until flow at the Virgelle gage station exceeded 396 m^3/sec (14,000 cfs). A flow of this magnitude was achieved during the first week of May, and a substantial increase of paddlefish was observed shortly thereafter in a survey count made from May 10 through 14 (Figure 16). Flow exceeded 396 m^3/sec for 50 consecutive days, May 4 through June 22, and paddlefish survey counts remained high throughout this time period. In late June, flow was reduced to slightly less than 396 m^3/sec, and most of the paddlefish returned to Fort Peck Reservoir. During the first three weeks of July, flow recovered to a level again exceeding 396 m^3/sec. However, there was no parallel recovery of the paddlefish run during this time period. Most of the paddlefish probably spawned before the flow reduction in late June. However, since flow at the Virgelle gage usually exceeds 396 m^3/sec through early July, the paddlefish spawning season may have been slightly shortened.

On May 23, 1978, an abnormally heavy rainstorm in the Highwood Mountains caused flooding in Arrow Creek, a tributary entering the Missouri River 154 km upstream from Fort Peck Reservoir. As a result of the flood a large amount of logs, tree branches, grass, and other organic debris was washed into the Missouri River and carried in suspension in the thalweg. Many migrant paddlefish in the Missouri River between the mouth of Arrow Creek and Fort Peck Reservoir encountered this debris, and it apparently clogged their mouths and gill rakers, weakening the fish. As a result, many paddlefish were forced downstream into Fort Peck Reservoir. On May 24, 1978, Bob Watts, a DFWP biologist from Lewistown, observed about 1000 to 1500 paddlefish in the Missouri River below Robinson Bridge drifting downstream near the surface of the water (Needham 1978). The fish were apparently under stress and exhausted from contending with debris.

As a result of this event, the abundance of migrant paddlefish in the Missouri River was temporarily reduced during late May and early June (Figure 16). However, by mid-June a significant recovery of the run was observed. The run probably would not have recovered if flows had not remained above 396 m^3/sec.

In 1979, five electrofishing survey runs were made on the Missouri River during a 60-day period from May 15 through July 13 (Table 15). Flow in the Missouri River in 1979 reached a near normal peak, but the duration of time during which flow exceeded 396 m^3/sec at the Virgelle gage station was greatly reduced, compared to 1978. Flow exceeded 396 m^3/sec at Virgelle for only 23 consecutive days, May 18 through June 9. By comparison flow exceeded this amount for 50 consecutive days in 1978. As an average for a 39-year period of record from 1940 through 1978, flow at the Virgelle gage exceeded 396 m^3/sec (14,000 cfs) for 48 consecutive days, May 19 through July 5 (USGS 1980).

Because of the shortened 1979 spring runoff period, the main portion of the spawning migration occurred during a more confined time period than in 1978 (Figures 16 and 17). A substantial movement of migrant paddlefish into the Missouri was observed shortly after flows surpassed 396 m^3/sec on May 18 at the Virgelle gage. Three hundred and thirty-seven paddlefish were counted in the river during a survey run made from May 26 through June 6 (Table 15). This was the highest paddlefish count made during the three-year study period, and it coincided with the peak flow observed in 1979 (Figure 17). On June 10, 1979, flow declined to less than 396 m^3/sec, and most of the paddlefish returned to Fort Peck Reservoir. Only 70 paddlefish

Table 15. Number of paddlefish counted in electrofishing survey runs on the middle Missouri River in 1979.

River Section	Census Dates, 1979				
	5/15-5/18	5/26-6/06	6/16-6/19	6/26-7/03	7/07-7/13
Fort Benton (281.1)1/ to Marias River (245.2)			0	0	
Marias River (245.2) to Coal Banks Landing (212.5)		10	0	1	0
Coal Banks Landing (212.5) to Hole-in-the-Wall (177.0)		7	13	11	5
Hole-in-the-Wall (177.0) to Judith Landing (135.6)	2	4	2	3	0
Judith Landing (135.6) to Stafford Ferry (113.9)	4	6	0	1	0
Stafford Ferry (113.9) to Bird Rapids (92.0)	4	14	8	4	0
Bird Rapids (92.0) to Cow Island (70.2)	4	16	0	1	0
Cow Island (70.2) to Grand Island (50.5)	11	148	15	6	1
Grand Island (50.5) to Robinson Bridge (37.3)	19	105	3	6	0
Robinson Bridge (37.3) to Slippery Ann (27.7)	10	18		6	
Slippery Ann (27.7) to Rock Creek (16.3)	0	3	(29)	1	(10)
Rock Creek (16.3) to Fort Peck Reservoir (0.0)	40	6		3	
Total	94	337	70	43	16

1/ River kilometers upstream from Fort Peck Reservoir.

Figure 16. Relationship between the total number of paddlefish counted in electrofishing surveys and discharge of the Missouri River at Virgelle in 1978.

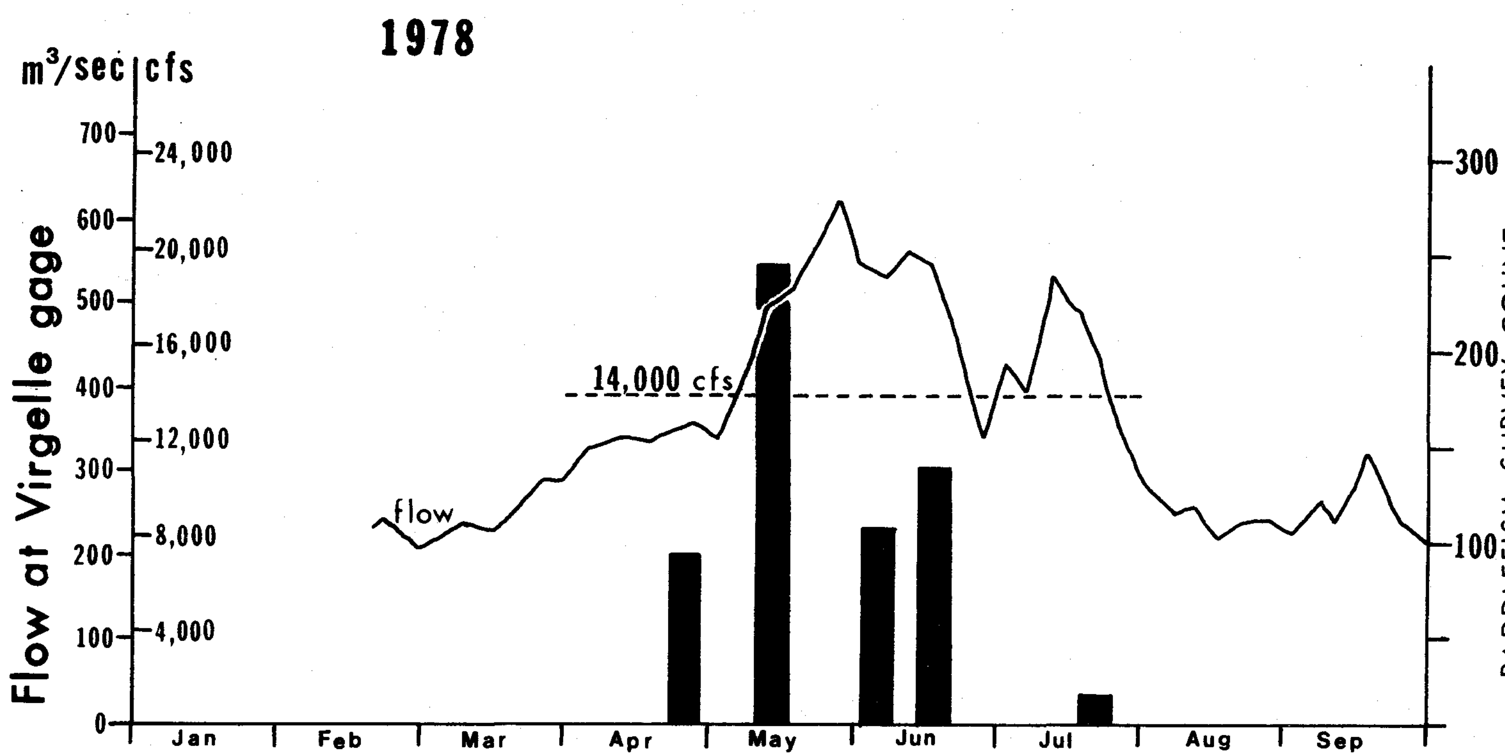
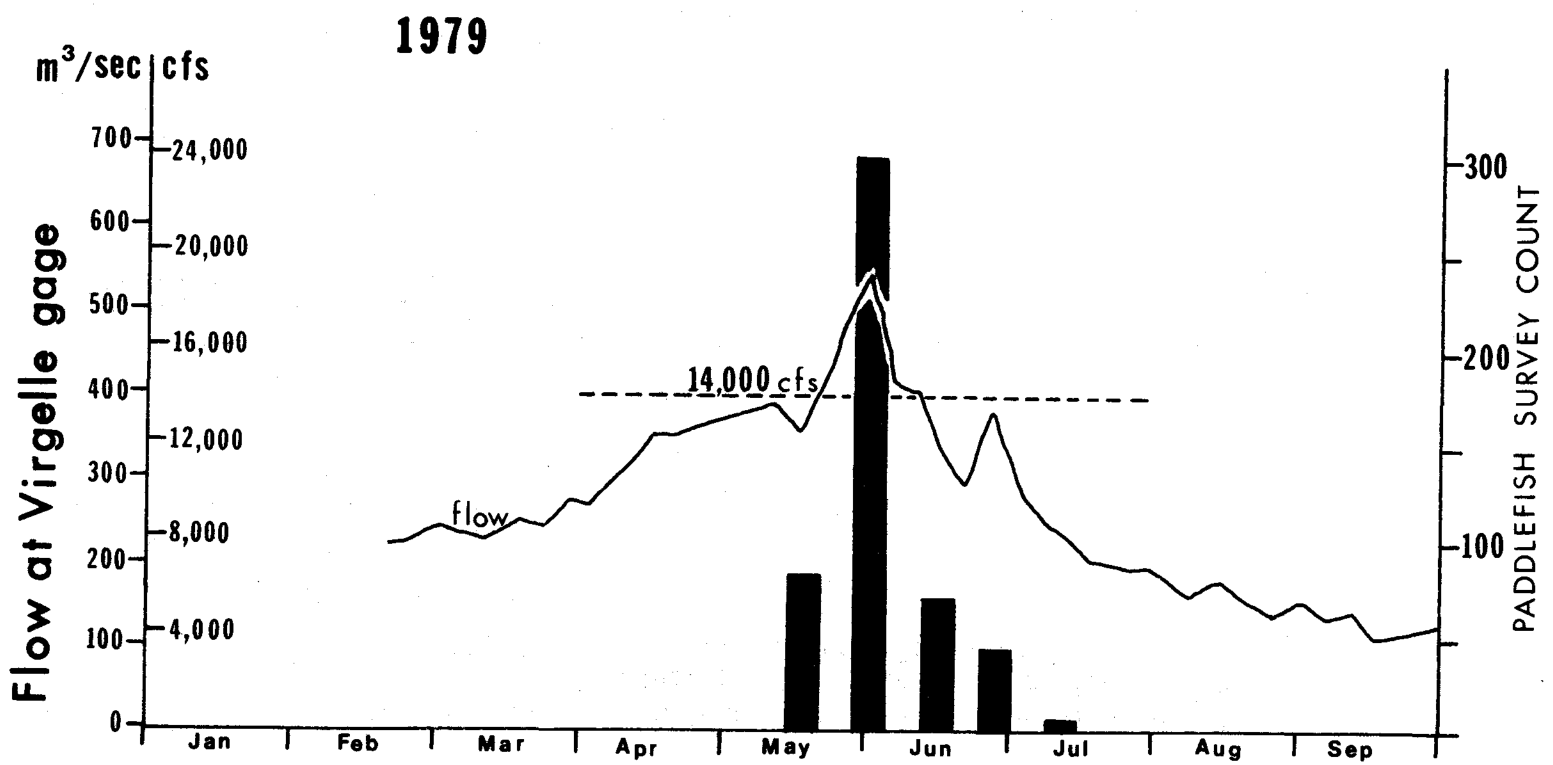


Figure 17. Relationship between the total number of paddlefish counted in electrofishing surveys and discharge of the Missouri River at Virgelle in 1979.



were observed in a survey count conducted from June 16 to 19, and 49 of these were found in the lower 37 km of river below Robinson Bridge. Documentation gathered during these studies indicates most paddlefish spawn in the Missouri River from early June through early July. Therefore, it is possible that a portion of the paddlefish in the 1979 run did not spawn before the flow declined in mid-June. If so, reproductive success of paddlefish in 1979 may have been poorer than average.

The farthest documented upstream movement of paddlefish in 1979 was seven paddlefish observed near Three Islands, a site located 233 km upstream from Fort Peck Reservoir. Six paddlefish were counted at Three Islands on June 5-6 and one on June 27.

Concentrations of paddlefish were observed at certain localities along the Missouri River during the migration periods in 1978 and 1979 (Figures 18 and 19). Ten areas of particular importance are:

1. Slippery Ann- Robinson Bridge area - river kilometers 29 to 37
2. Upper and Lower Two Calf Islands area - river kilometers 45 to 50
3. Cow Island - Powerplant Ferry area - river kilometers 56 to 71
4. Bullwhacker Creek area - river kilometers 78 to 79
5. Dauphine Rapids area - river kilometers 113 to 116
6. Holmes Rapids area - river kilometers 129 to 132
7. Deadmans Rapids area - river kilometers 137 to 142
8. Little Sandy Creek area - river kilometers 195 to 211
9. Virgelle Ferry - Boggs Island area - river kilometers 216 to 222
10. Three Islands area - river kilometers 233 to 235.

Although these ten areas encompassed only 64 km, or 19 percent, of the 333-km reach of free-flowing Missouri River between Morony Dam and Fort Peck Reservoir, they contained 87 percent of the migrant paddlefish observed during the electrofishing survey counts. It is very significant that the paddlefish observed in 1979 inhabited the same ten sites that were occupied in 1978. The recurrent use emphasizes the importance of these sites as paddlefish habitat.

The Slippery Ann - Robinson Bridge area does not appear to contain gravel bars suitable for paddlefish spawning. However, the site is important as a "staging" area for paddlefish which inhabit the area prior to or following extended migrations to upstream spawning areas.

The remaining nine paddlefish concentration areas are important spawning sites. The following evidence was gathered during the study to support this conclusion:

1. All nine sites contained extensive silt-free gravel bars of a type described by Purkett (1961) as being suitable for paddlefish spawning.
2. Numerous paddlefish were observed in electrofishing survey counts conducted at the nine sites in both 1978 and 1979. The total number of paddlefish observed at the sites ranged from 10 at the Bullwhacker Creek site to 411 at the Cow Island - Powerplant Ferry site.
3. The paddlefish were observed at the nine sites during their known spawning period.

Figure 18. Number of paddlefish observed at various localities along the Missouri River in electrofishing census runs made during the migration period in 1978.

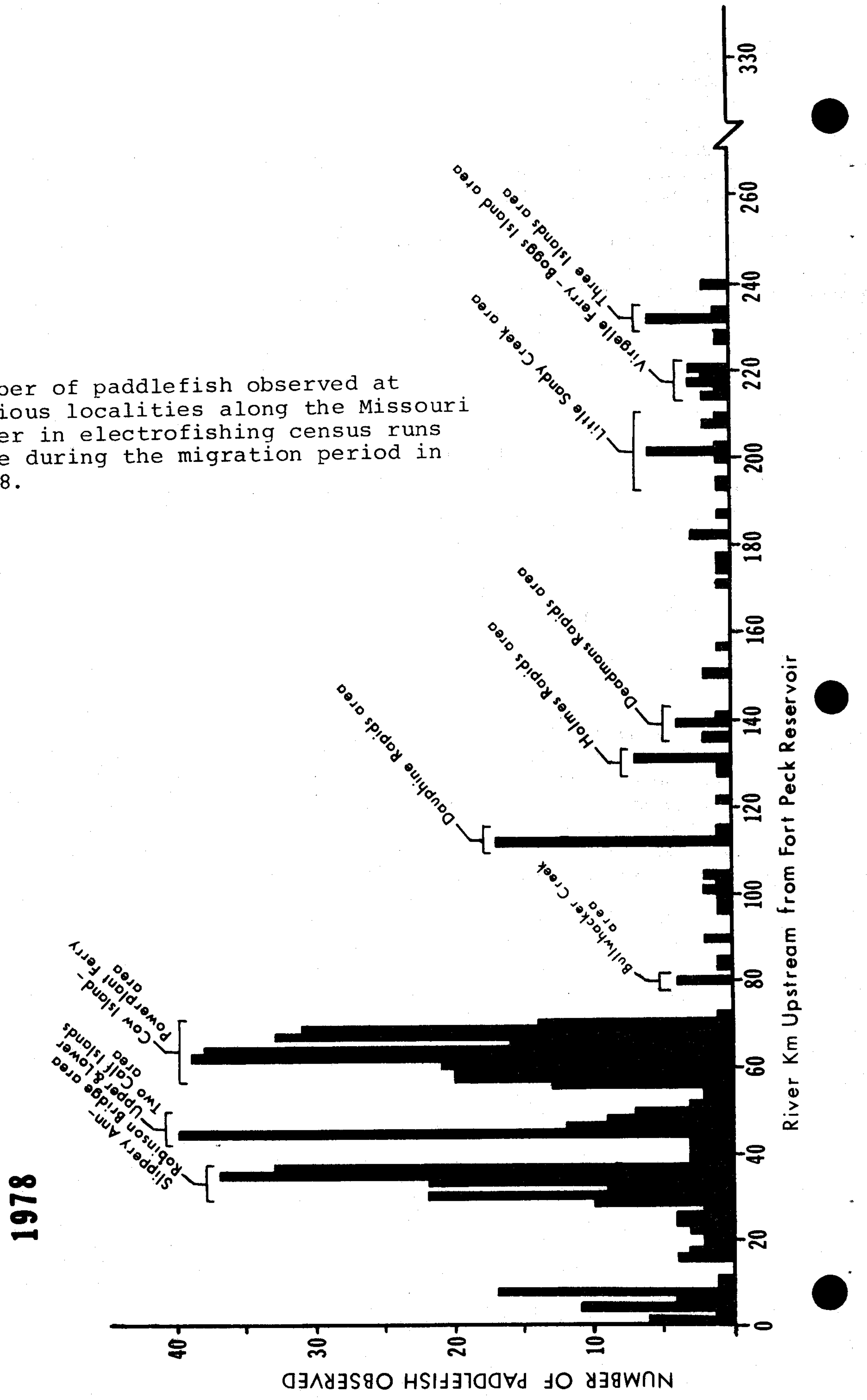
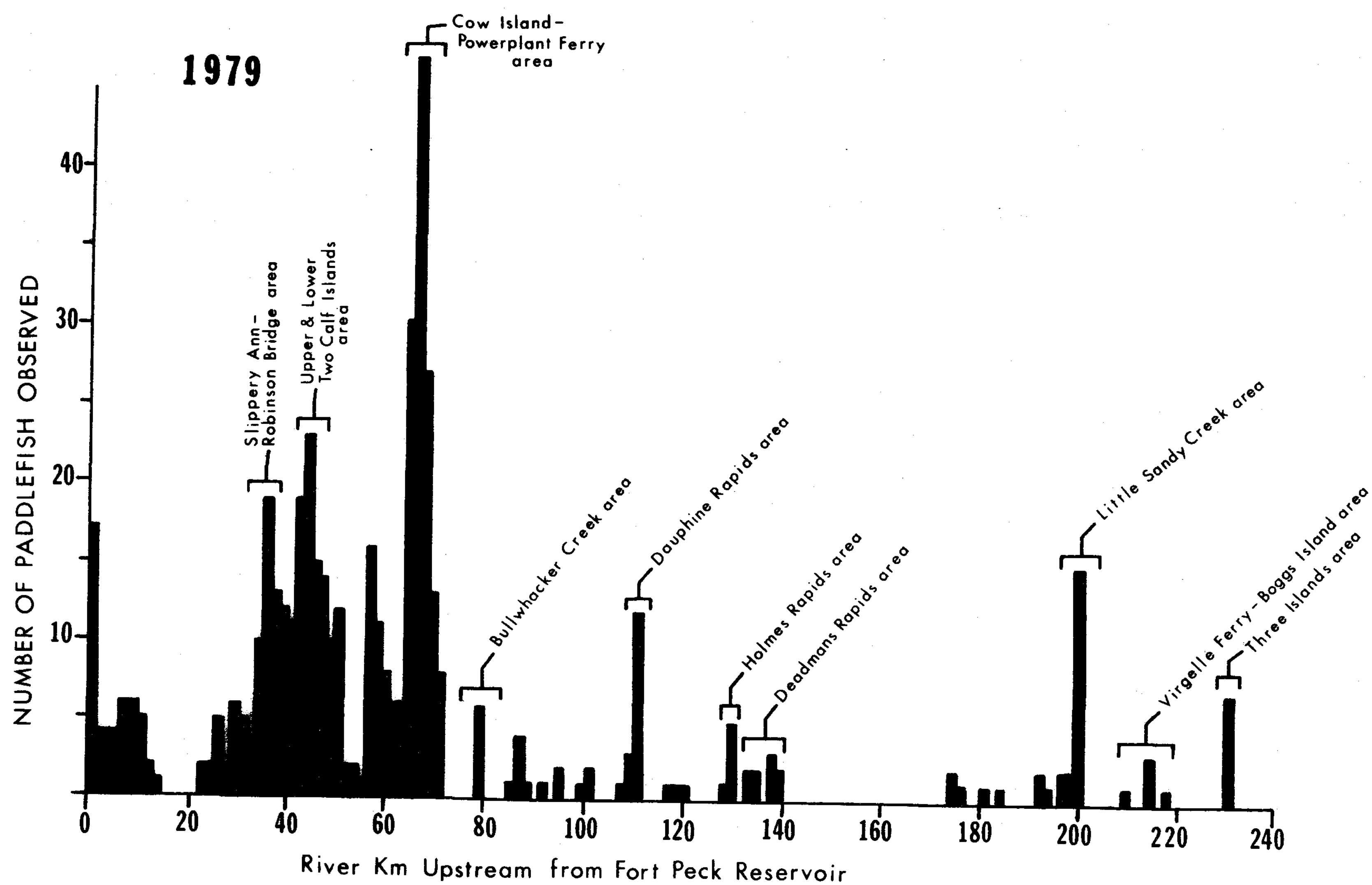


Figure 19. Number of paddlefish observed at various localities along the Missouri River in electrofishing survey runs made during the migration period of 1979.



4. Sexually mature paddlefish were captured, tagged, and released in five of the nine sites, including Little Sandy Creek, Holmes Rapids, Dauphine Rapids, Cow Island - Powerplant Ferry, and Upper and Lower Two Calf Islands (Table 16).
5. Spawning activity, as described for paddlefish on the Osage River by Purkett (1961), was observed at four of the nine sites. Purkett indicated most paddlefish spawning activity occurred underwater, but the spawning behavior also involved appearances on the surface of the water. Spawning paddlefish visible at the surface agitated the caudal fin several times, then disappeared after a few seconds. Specific spawning sites were tentatively identifed on the Osage River by observing paddlefish which continued to surface in one place. When the river level declined, Purkett found attached eggs and newly hatched larvae in these areas. Spawning activity was observed on May 23 and June 14, 1978, at the Little Sandy Creek site, on June 15 and June 27, 1978, at the Dauphine Rapids site, on June 16, 1979, at the Cow Island - Powerplant Ferry site, and on June 17, 1979, at the Upper and Lower Two Calf Islands site.
6. Two paddlefish prolarvae were collected on the Missouri River in 1978, one at Coal Banks Landing on July 12 and one at Little Sandy Creek on July 13. This finding confirms that paddlefish spawn successfully in the farthest upstream spawning sites which have been identified.
7. An incubating paddlefish egg was collected at the Dauphine Rapids spawning site on June 12, 1979. Identification of this egg was confirmed at the TVA fish repository in Norris, Tennessee. The egg was developed to the 55-hour embryo stage as described by Ballard and Needham (1964). Thus, the egg was spawned at the site on June 10, 1979.

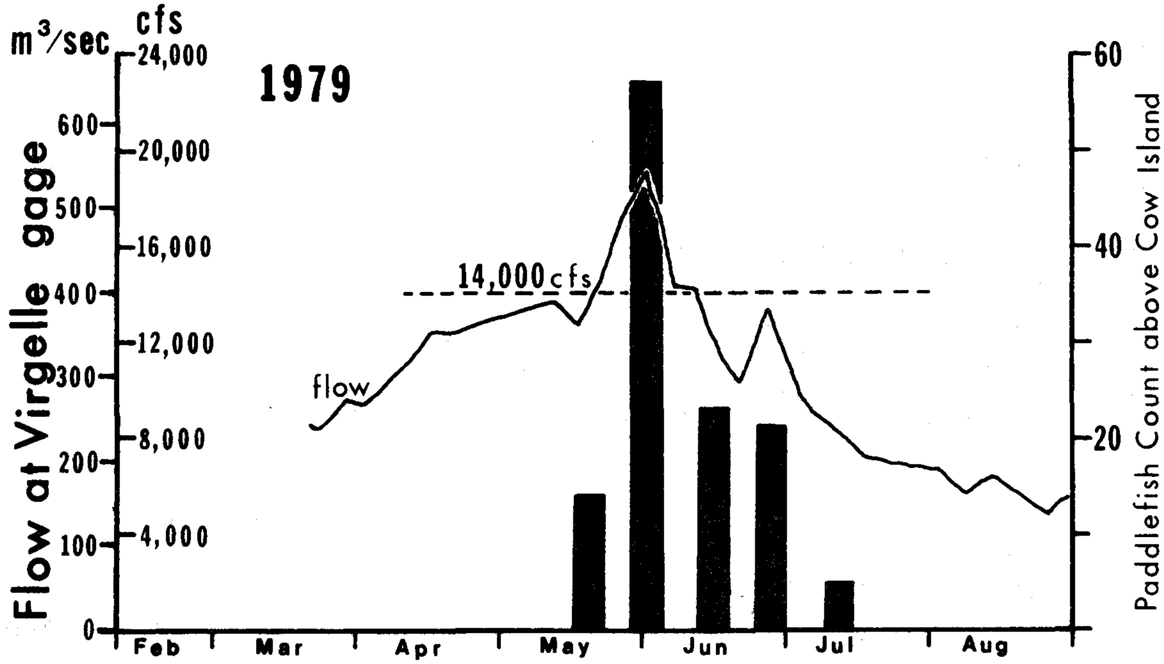
Numbers of paddlefish observed at the nine spawning sites do not necessarily indicate the relative importance of the sites for spawning. For example, the largest numbers of paddlefish in electrofishing surveys were observed in the Cow Island - Powerplant Ferry area. While the concentration of paddlefish in this area was probably related in part to suitability of the site for spawning, it was also apparent that physical characteristics of the river in the vicinity of Cow Island (shallow, swift water) acted as a partial barrier to upstream passage of paddlefish. Large concentrations of paddlefish were often found in a 16-km section of river located immediately below Cow Island. Significant movements of paddlefish to the seven spawning sites located upstream from Cow Island did not occur until flow at the Virgelle gage station exceeded 396 m^3/sec (14,000 cfs) (Figure 20). Since most of the spawning areas are located upstream from Cow Island, flow should be maintained in excess of 396 m^3/sec whenever possible during the spawning period to allow passage past the island.

In summary, the nine paddlefish spawning sites and the "staging" area below Robinson Bridge are critical habitat areas for the Missouri River - Fort Peck Reservoir paddlefish population. Efforts must be made to protect the sites so paddlefish use can continue undiminished. These efforts are particularly important because of the tenuous status of paddlefish in the United States today.

Table 16. Date of capture, sex and size paddlefish tagged at spawning sites on the middle Missouri River in 1978 and 1979.

Spawning Site	Tag Date	Tag Location[1/]	Total Length (cm)	Fork Length (cm)	Weight (kg)	Sex	Tag No.
Little Sandy Creek	5-23-78	203	185	163	36.7	Female	249
Little Sandy Creek	6-29-79	203	140	124	11.3	Male	940
Holmes Rapids	5-11-78	129	154	138	19.5	Male	244
Dauphine Rapids	6-15-78	113	188	171	44.5	Female	250
Cow Island	4-27-78	64	147	136	21.3	Female	238
Cow Island	4-27-78	58	133	119	10.4	Male	232
Cow Island	5-12-78	64	166	151	30.4	Female	245
Cow Island	5-13-78	58	141	127	14.1	Male	246
Cow Island	5-13-78	56	136	123	15.9	Male	247
Cow Island	6-15-78	69	150	136	15.9	Male	256
Cow Island	6-16-78	61	128	116	8.2	Male	257
Cow Island	5-27-79	71	128	117	12.7	Male	931
Cow Island	5-27-79	66	139	127	14.5	Male	932
Cow Island	5-27-79	64	150	141	29.5	Female	933
Cow Island	5-27-79	63	160	148	20.9	Male	934
Cow Island	5-28-79	60	143	130	16.8	Male	935
Cow Island	6-16-79	69	152	138	20.4	Female	939
Two Calf	4-27-78	47	144	130	15.9	Male	240
Two Calf	4-27-78	45	151	138	23.6	Male	241
Two Calf	5-13-78	50	183	166	49.9	Female	248
Two Calf	5-28-79	45	179	171	44.5	Female	938

1/ River kilometers upstream from Fort Peck Reservoir.



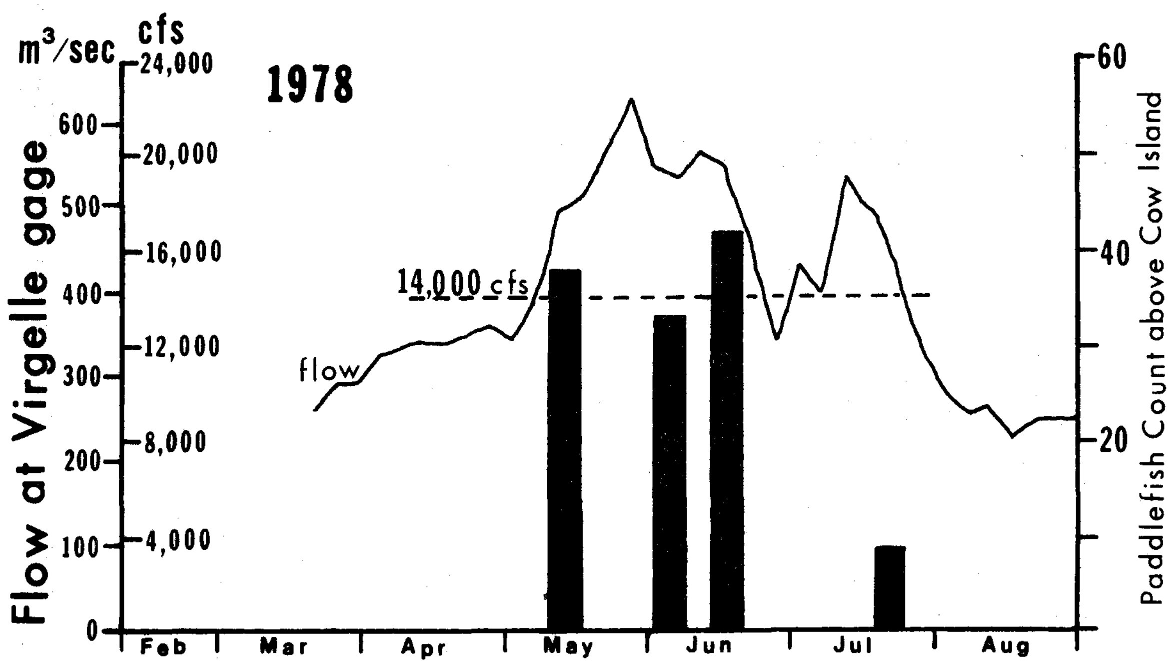


Figure 20. Number of paddlefish counted in electrofishing surveys above Cow Island compared to discharge of the Missouri River at Virgelle in 1978 and 1979.

Spawning Periods of Fish in the Missouri River Mainstem

Spawning periods were determined for 18 fish species in the mainstem of the middle Missouri River. The spawning period was defined as the time between the first observation of a spent or partly spent female to the last observation of a ripe female. Larval fish collections were used to aid in determining the spawning period for some species. Spawning chronology of the 18 fish species is illustrated in Figure 21. The spawning periods represent a four-year composite for the inventory period, 1976 through 1979.

Walleye, sauger, northern pike, goldeye, and longnose sucker were relatively early spawners; all began spawning in April. Walleye spawning peaked in late April. Sauger, northern pike, goldeye, and Catostominae (suckers and redhorse) spawned primarily in May, while shovelnose sturgeon, paddlefish, and Ictiobinae/Cyprinidae (river carpsucker, buffalo, and minnows) spawned primarily in June and early July. Channel catfish spawning peaked during the first three weeks of July.

Seasonal Migrations of Fish in the Missouri River Mainstem

Information on seasonal migrations of common fish species in the study area was provided by electrofishing catch rates. Electrofishing data indicated shovelnose sturgeon made a significant seasonal spawning movement from the lower portion of the middle Missouri River into the Coal Banks Landing and Loma Ferry study sections. The shovelnose sturgeon spawning period in the Missouri River extends from late May through early July. From 1976 through 1979, an average of 0.9 shovelnose sturgeon per electrofishing hour was sampled in the Coal Banks Landing and Loma Ferry study sections in early May. During the peak of the shovelnose sturgeon spawning period in early June, the catch rate increased to an average of 2.2 sturgeon per electrofishing hour in these study sections. By late June the catch rate decreased to 0.9 sturgeon per electrofishing hour, probably indicating that many of the fish had spawned and dispersed back downstream.

It is not known if shovelnose sturgeon actually spawn in the Coal Banks Landing and Loma Ferry study sections or if this is a staging area for sturgeon which spawn in the Marias River. Shovelnose sturgeon prolarvae have been collected in the lower Marias River, indicating that successful reproduction occurs there. While shovelnose sturgeon spawning has not been verified in the mainstem of the middle Missouri River, the presence of substantial numbers of ripe male and female sturgeon in the Coal Banks Landing and Loma Ferry study sections during the spawning period suggests that some spawning could occur in the mainstem. The Coal Banks Landing and Loma Ferry study sections contain significant amounts of silt-free gravel bars. Although little is known about the spawning habits of shovelnose sturgeon, Pflieger (1975) indicated they evidently spawn in the open channels of large rivers, in a strong current, and over gravelly bottoms. Morris et al. (1974) also indicated that shovelnose sturgeon spawn over gravel, and they have been observed moving upstream prior to spawning, sometimes for considerable distances.

One of the most substantial fish movement patterns observed in the middle Missouri River was the seasonal migration of sauger from the lower river into the reach between Fort Benton and Morony Dam. Sauger movement into the upper portion of the river occurred during the spring and summer.

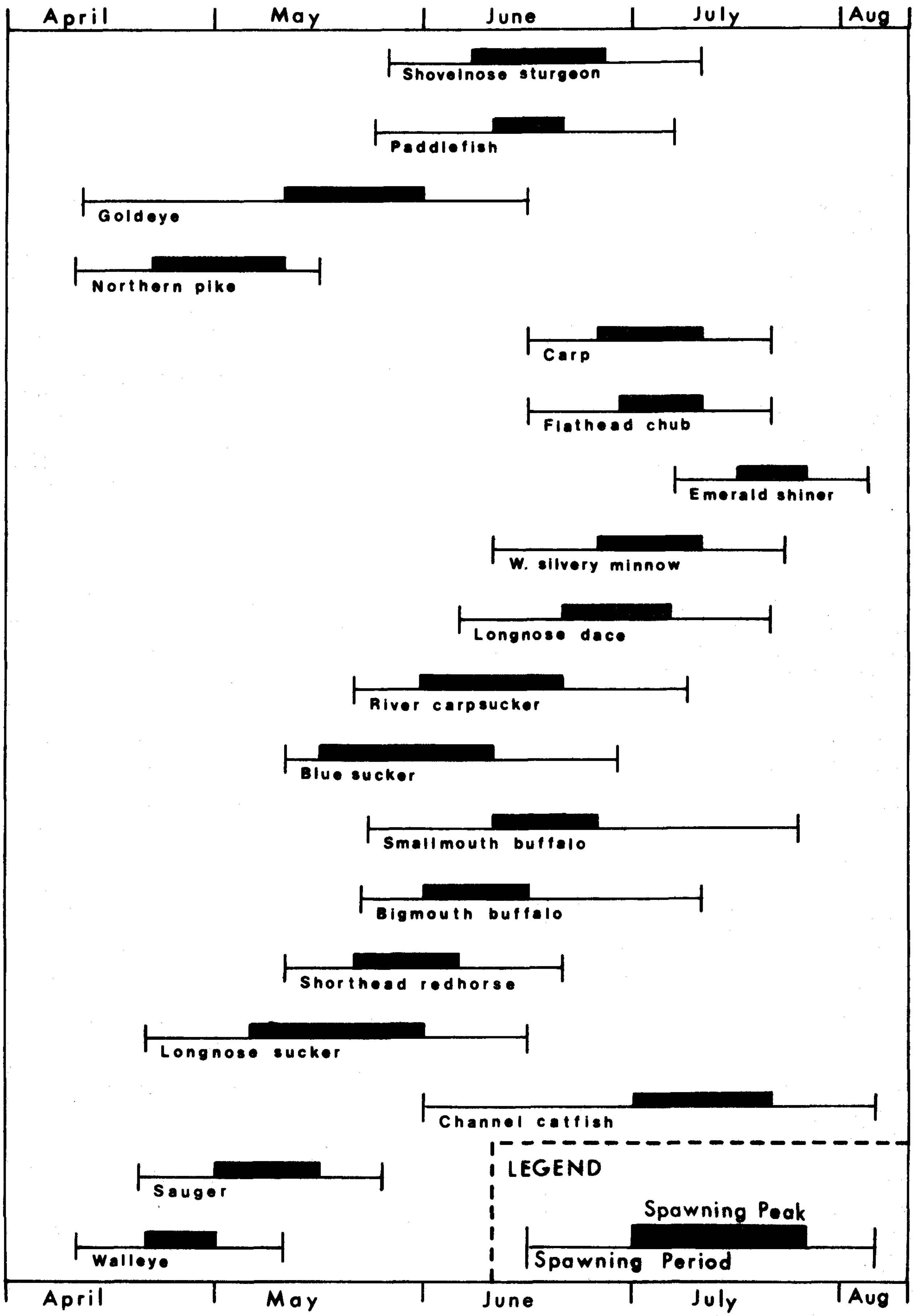


Figure 21. Observed spawning chronology of eighteen fish species sampled in the middle Missouri River from 1976 through 1979.

The catch rate of sauger in the upper river gradually increased prior to, during, and following the spawning period which peaked in early May. The early spring movements of sauger were related to spawning, while movements later in the summer were probably related to feeding.

The increased concentration of sauger was particularly evident in the Morony Dam study section where the catch rate increased from an average of 0.2 sauger per electrofishing hour in late March to 12.0 sauger per hour during the spawning period in May. The catch rate continued to gradually increase to a peak of 28.8 sauger per hour in August, and then it decreased to an average of 9.5 sauger per hour in October. The catch rates represent a composite average for the period from 1976 through 1979.

In the Carter Ferry study section, located between Morony Dam and Fort Benton, the catch rate increased from an average of 0.6 sauger per hour in late March to 10.0 sauger per hour during the spawning period in May. In August, the catch rate reached a peak of 18.7 sauger per hour. By late October, the catch rate decreased to 7.5 sauger per hour, indicating that many of the fish had dispersed back downstream.

Sauger movement trends in the Fort Benton study section were similar to those observed in the Morony Dam and Carter Ferry sections, but seasonal changes were less pronounced. Catch rates in the Fort Benton study section were 2.5 sauger per electrofishing hour in late March, 7.5 sauger per hour during the spawning period in May, 9.9 sauger per hour in August, and 9.5 sauger per hour in October.

The reach of Missouri River between Morony Dam and Fort Benton is obviously critical sauger habitat. Large numbers of sauger in a ripe spawning condition are found in this area during the spring spawning period. In addition, a spawning run of sauger from the Missouri River occurs in lower Belt Creek, a tributary which enters the Missouri River 1.9 kilometers below Morony Dam (Posewitz 1963 and Al Wipperman, DFWP, personal communication). Forage fish, which comprise the principal portion of the sauger diet, are very abundant in the Missouri River between Morony Dam and Fort Benton. Several important forage species, including longnose dace, mottled sculpin, mountain suckers, and juvenile shorthead redhorse and longnose suckers are significantly more abundant upstream from Fort Benton than in downstream areas (Table 10). Tag return evidence indicates that sauger using the Missouri River upstream from Fort Benton come from areas as far downstream as the headwaters of Fort Peck Reservoir, a distance of approximately 280 km. Sauger movements indicated by tag returns will be discussed in greater detail in the next section of this report.

In summary, the Missouri River from Morony Dam to Fort Benton provides food production and spawning sites for sauger from as far downstream as Fort Peck Reservoir. Protection of this critical habitat area is essential.

Electrofishing data also indicated that blue suckers, smallmouth buffalo, and bigmouth buffalo made significant seasonal movements from the lower portions of the river into upstream areas. Large numbers of blue suckers and buffalo were found during their spawning period in the Coal Banks Landing, Loma Ferry, and Fort Benton study sections, and some were found seasonally as far upstream as the Morony Dam study section. The seasonal movement of blue suckers and buffalo was evidently related to spawning since most of the fish dispersed back downstream shortly after the spawning period.

Several additional species of fish, including goldeye, river carpsuckers, shorthead redhorse and others, made extensive seasonal movements. However, electrofishing data were not adequate to evaluate movement patterns of these species.

Movements of Fish as Indicated by Tag Returns

A total of 8165 fish of 17 species were marked with individually numbered tags during the period, October 1, 1975 through October 1, 1980. Of this total, 6992 fish were tagged in the mainstem of the Missouri River from Morony Dam to Fort Peck Reservoir, and 1001, 131, and 41 were tagged in the lower Marias, Teton, and Judith rivers, respectively. The species tagged included 3950 sauger, 1926 channel catfish, 814 shovelnose sturgeon, 423 blue suckers, 287 smallmouth buffalo, 216 freshwater drum, 169 burbot, 131 mountain whitefish, 97 bigmouth buffalo, 40 walleye, 40 northern pike, 28 brown trout, 21 white crappie, 18 rainbow trout, 2 brook trout, 2 yellow perch, and 1 pallid sturgeon.

Of the 8165 fish tagged, 276 were recaptured in subsequent research surveys or by anglers (Table 17). The recaptures included 168 sauger, 66 channel catfish, 12 shovelnose sturgeon, 6 blue suckers, 6 smallmouth buffalo, 6 walleye, 3 northern pike, 3 burbot, 2 freshwater drum, 2 brown trout, 1 bigmouth buffalo, and 1 mountain whitefish. The recaptures provided significant information about movement patterns of several species.

Sauger

Tag return data indicated that sauger moved considerable distances in the Missouri River and its tributaries. Of 168 sauger recaptured, 127 (76 percent) moved 1 km or more from the site where they were tagged. Distances moved by individual fish ranged from 1 to 295 km upstream and from 1 to 246 km downstream (Table 17). The tag return data indicate that sauger move throughout the entire river from Morony Dam to Fort Peck Reservoir.

Other researchers have also reported extensive movements of sauger in rivers. Graham et al. (1979) found numerous sauger which moved more than 100 km upstream or downstream in the lower Yellowstone River, Montana. The maximum distances moved in the lower Yellowstone were 417 km downstream and 269 km upstream. Posewitz (1963) observed sauger movements of up to 87 km upstream and 32 km downstream in the lower Marias River, Montana. Morris (1969) reported downstream movements of up to 124 km below the stilling basin of Gavins Point Dam on the Missouri River, Nebraska.

A seasonal migration of sauger from the lower portion of the middle Missouri River into the reach between Fort Benton and Morony Dam was described in the previous section of this report. Numerous recaptures of individually tagged sauger provided additional evidence of this movement pattern. Twenty-nine sauger tagged upstream from Fort Benton were subsequently recaptured downstream from Fort Benton. Most of the recaptured fish were tagged upstream from Fort Benton during spring and summer (mid-April through mid-September). Most of the downstream recoveries were made in the late fall or early spring.

Nineteen sauger tagged downstream from Fort Benton were recaptured in the Missouri River upstream from Fort Benton. Most of these fish were tagged downstream in the late fall or early spring, and most of the recoveries

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag		Recapture		Time at	Distance Moved in Missouri River (km)		Distance Moved in Tributary (km)		Total Distance
Date	Location[1/]	Date	Location[1/]	Large (Days)	Upstream	Downstream	Upstream	Downstream	Moved (km)
Sauger Tagged in Missouri River Above Confluence of Marias River									
10-22-76	MD 312	4-19-77	MD 327	179	15				15
7-19-78	MD 320	4-27-80	MR 2	647		75	2		77
8-11-79	MD 322	3-20-80	CB 217	221		105			105
8-11-79	MD 322	5- 2-80	MR 2	264		77	2		79
8-12-79	MD 323	4-29-80	MR 2	260		78	2		80
8-11-79	MD 322	8-14-79	MD 320	3		2			2
8-15-79	MD 312	4-16-80	FB 278	244		34			34
8-14-79	MD 323	8-20-79	MD 325	6	2				2
8-20-79	MD 325	10-13-79	MD 325	54					0
8-20-79	MD 320	4-21-80	MR 34	244		75	34		109
8-14-79	MD 320	8-20-79	MD 320	6					0
8-12-79	MD 320	9-11-79	MD 322	30	2				2
8-11-79	MD 322	9-11-79	MD 322	31					0
8-20-79	MD 325	9-11-79	MD 322	22		3			3
8-15-79	MD 315	9-11-79	MD 314	27		1			1
8-12-79	MD 312	9-11-79	MD 314	30	2				2
8-20-79	MD 312	9-11-79	MD 312	22					0
8-15-79	MD 312	9-11-79	MD 312	27					0
9-11-79	MD 322	10-24-79	MD 314	43		8			8
8-12-79	MD 312	9-12-79	CF 307	31		5			5
5-10-80	MD 323	7- 2-80	MD 333	53	10				10
7-19-78	MD 320	5-12-79	MR 3	297		75	3		78
9-11-79	MD 314	4-29-80	FB 285	230		29			29
8-20-79	MD 320	4-29-80	FB 285	252		35			35
10-24-79	MD 314	5-10-80	MD 322	198	8				8
8-12-79	MD 312	5-10-80	MD 312	271					0
8-15-79	MD 315	5-10-80	LF 259	268		56			56
8-12-79	MD 323	5-24-80	LF 251	285		72			72
8-14-79	MD 323	6- 9-80	LF 248	299		75			75
8-15-79	MD 315	6- 9-80	LF 248	298		67			67

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag Date	Tag Location 1/	Recapture Date	Recapture Location 1/	Time at Large (Days)	Distance Moved in Missouri River (km) Upstream	Distance Moved in Missouri River (km) Downstream	Distance Moved in Tributary (km) Upstream	Distance Moved in Tributary (km) Downstream	Total Distance Moved (km)
Sauger Tagged in Missouri River Above Confluence of Marias River									
8-22-78	CF 307	7-31-79	MD 333	343	26				26
8-23-78	CF 293	4-10-80	FB 278	595		15			15
8-23-78	CF 294	7-16-79	CF 294	327					0
7-17-79	CF 294	7- 8-80	FB 280	356		14			14
7-17-79	CF 294	4-14-80	MR 3	271		49	3		52
8-23-78	CF 307	8- 7-79	CF 307	349					0
8-21-79	CF 294	9-12-79	CF 294	22					0
8-15-78	CF 293	6-18-79	LF 259	307		34			34
8-15-78	CF 298	5-19-79	MR 6	277		53	6		59
8-14-78	CF 309	5-19-79	MR 3	278		64	3		67
9-12-79	CF 294	4- 9-80	FB 280	209		14			14
8-21-79	CF 306	4- 9-80	LF 259	231		47			47
7-17-79	CF 294	6- 9-80	LF 241	328		53			53
8-23-78	FB 282	7-17-79	CF 294	329	12				12
8- 9-76	FB 285	9- 1-77	FB 280	389		5			5
8-19-76	FB 274	9- 6-76	FB 278	19	4				4
9-20-76	FB 290	3-15-77	FB 280	178		10			10
9-17-76	FB 280	9-20-76	FB 286	3	6				6
9-20-76	FB 286	12-22-76	FB 278	93		8			8
7-30-76	FB 280	9-20-76	FB 283	52	3				3
9-20-76	FB 283	3-15-77	FB 280	178		3			3
9-20-76	FB 280	12- 3-76	FB 280	74					0
9-17-76	FB 280	9-20-76	FB 280	3					0
9-20-76	FB 280	9-20-76	FB 280	0					0
9-20-76	FB 280	9-21-76	FB 280	1					0
9-17-76	FB 280	9-24-76	FB 280	7					0
9-24-76	FB 280	12-22-76	FB 278	89		2			2
8-19-76	FB 274	3-22-77	FB 280	216	6				6
3-22-77	FB 280	3-25-77	FB 286	3	6				6
3- 9-77	FB 280	3-25-77	FB 286	16	6				6
3-25-77	FB 286	9- 1-77	FB 280	160		6			6

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag		Recapture		Time at Large (Days)	Distance Moved in Missouri River (km)		Distance Moved in Tributary (km)		Total Distance Moved (km)
Date	Location[1/]	Date	Location[1/]		Upstream	Downstream	Upstream	Downstream	
Sauger Tagged in Missouri River Above Confluence of Marias River									
3- 9-77	FB 280	3-25-77	FB 283	16	3				3
3-22-77	FB 280	3-25-77	FB 283	3	3				3
3- 9-77	FB 280	3-25-77	FB 283	16	3				3
3-25-77	FB 280	5-30-77	LF 251	66		29			29
5-26-77	FB 274	6- 1-77	FB 280	6	6				6
7-20-78	FB 280	9-10-78	FB 280	52					0
5- 8-78	FB 280	8-15-78	FB 280	99					0
6- 7-78	FB 280	6-24-78	MD 333	17	53				53
5-26-77	FB 277	6-26-79	FB 272	762		5			5
4-13-79	FB 280	10-20-79	FB 280	190					0
9-17-76	FB 280	5-10-77	MR 8	237		35	8		43
3-25-77	FB 283	5-12-79	MR 6	779		38	6		44
5- 2-78	FB 285	8-10-79	MR 114	466		40	114		154
4-10-80	FB 280	5-10-80	CF 298	30	18				18
9-10-79	FB 270	5-24-80	FB 275	258	5				5
4-20-78	FB 277	8- 6-80	FB 280	840	3				3
9-22-78	LF 257	8-12-79	MD 312	326	55				55
9-21-76	LF 248	6-24-78	MD 320	643	72				72
9-21-76	LF 248	3-27-77	RB 27	189		221			221
9-21-76	LF 249	9-22-76	LF 248	1		1			1
9-22-76	LF 248	9-23-76	LF 251	1	3				3
9-21-76	LF 248	9-23-76	LF 248	2					0
9-21-76	LF 248	9-23-76	LF 248	2					0
9-22-76	LF 248	8-16-78	LF 249	695	1				1
7-24-79	LF 254	5- 2-80	MR 2	283		9	2		11
9-22-78	LF 254	7-27-79	LF 256	310	2				2
8-16-78	LF 257	7-31-79	LF 259	350	2				2
9-21-76	LF 248	8-25-77	TJ 2	340		246			246
9-22-76	LF 248	4-29-77	MR 2	221		3	2		5
9-10-79	LF 251	5-24-80	LF 251	258					0
9-21-76	LF 248	6- 9-80	LF 241	993		7			7

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag		Recapture		Time at	Distance Moved in Missouri River (km)		Distance Moved in Tributary (km)		Total
Date	Location1/	Date	Location1/	Large (Days)	Upstream	Downstream	Upstream	Downstream	Distance Moved (km)
				Sauger Tagged in Missouri River Below Confluence of Marias River					
6- 5-79	LF 232	9-12-79	CF 294	99	62				62
8-12-76	LF 241	8- 1-77	LF 248	355	7				7
8- 1-79	LF 235	8-28-79	LF 235	27					0
10-17-78	LF 230	6- 6-79	LF 212	233		18			18
11- 3-78	LF 240	6-17-79	MR 8	228	5		8		13
6-29-77	LF 238	5-10-80	CB 224	1047		14			14
6-18-79	CB 212	8-15-79	MD 322	58	110				110
6-29-77	CB 211	7-20-78	FB 283	388	72				72
7-19-77	CB 203	7-27-79	LF 259	739	56				56
10-12-76	CB 209	10-13-76	CB 204	1		5			5
10-12-76	CB 209	10-13-76	CB 204	1		5			5
10-12-76	CB 209	6-14-77	CB 203	246		6			6
10-22-77	CB 203	9-25-78	FB 280	339	77				77
6-14-77	CB 220	7-12-79	CB 220	760					0
6- 6-79	CB 212	7-12-79	CB 212	36					0
6-15-77	HW 161	5-16-79	JL 142	702		19			19
9-27-76	JL 137	10-10-76	JL 142	13	5				5
9-27-76	JL 137	10- 9-76	SF 114	12		23			23
9-28-76	JL 137	9-29-76	JL 137	1					0
9-29-76	JL 137	5- 1-80	MD 320	1311	183				183
9-29-76	JL 137	4-27-77	RB 27	212		110			110
9-29-76	JL 137	9-30-76	JL 137	1					0
9-27-76	JL 137	9-30-76	JL 132	3		5			5
9-30-76	JL 132	10- 1-76	JL 137	1	5				5
9-30-76	JL 132	7-29-77	JL 137	304	5				5
10- 1-76	JL 129	7-29-77	JL 137	302	8				8
7-13-79	JL 137	9- 2-79	JL 135	51		2			2
8- 1-77	JL 135	9-30-77	FB 280	60	145				145
9-29-76	JL 137	5-19-77	RB 27	234		110			110

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag		Recapture		Time at Large (Days)	Distance Moved in Missouri River (km)		Distance Moved in Tributary (km)		Total Distance Moved (km)
Date	Location 1/	Date	Location 1/		Upstream	Downstream	Upstream	Downstream	
Sauger Tagged in Missouri River Below Confluence of Marias River									
9-28-76	JL 137	9-22-79	JR 3	1091	1		3		4
5-16-79	CI 84	11-16-79	PK 47	184		131*			131
4- 5-77	RB 27	9-11-79	MD 322	891	295				295
4-13-77	RB 27	6- 3-79	MR 2	783	218		2		220
4-13-77	RB 27	4-20-77	RB 27	7					0
4-20-77	RB 27	4-29-77	RB 27	9					0
5-18-77	RB 27	5-19-77	RB 27	1					0
4- 6-77	TJ 6	4-25-80	MR 2	1116	239		2		241
4- 9-77	TJ 3	4-23-77	TJ 5	14	2				2
4-21-77	TJ 3	5-11-77	TJ 3	20					0
4-21-77	TJ 3	6-22-78	FB 280	429	277				277
4- 7-77	TJ 2	8-10-77	TJ 3	125	1				1
4- 9-77	TJ 3	8-10-77	TJ 2	123		1			1
8-10-77	TJ 2	8-12-77	TJ 2	2					0
8-10-77	TJ 2	8-15-77	TJ 2	5					0
8-15-77	TJ 2	11- 6-78	RB 27	449	25				25
4- 9-77	TJ 2	8-15-77	TJ 2	128					0
8-16-77	TJ 2	8-31-78	TJ 2	380					0
8-15-77	TJ 2	8-24-77	TJ 2	9					0
8-26-77	TJ 2	10-13-79	TJ 2	779					0
8-13-77	TJ 2	8-26-77	TJ 2	13					0
8-29-77	TJ 2	5- 2-79	TJ 5	612	3				3
8-15-77	TJ 2	9- 1-78	TJ 2	383					0
8-15-77	TJ 2	9- 1-78	TJ 2	383					0
8-24-77	TJ 2	9- 1-78	TJ 2	374					0
8-10-77	TJ 3	9-10-79	TJ 2	762		1			1

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag Date	Tag Location[1/]	Recapture Date	Recapture Location[1/]	Time at Large (Days)	Distance Moved in Missouri River (km) Upstream	Distance Moved in Missouri River (km) Downstream	Distance Moved in Tributary (km) Upstream	Distance Moved in Tributary (km) Downstream	Total Distance Moved (km)
				Sauger Tagged in Tributaries of Missouri River					
5-29-79	MR 10	7-23-79	CF 299	55	54			10	64
5-12-79	MR 3	9-10-79	LF 259	121	14			3	17
6-20-78	MR 3	10-17-78	CB 219	119		26		3	29
4-15-77	MR 2	5-30-77	LF 251	45	6			2	8
5-20-77	MR 2	4-26-78	LF 241	342		4		2	6
5-24-77	MR 6	6-15-77	FB 280	22	35			6	41
7- 6-77	MR 3	7- 9-77	MR 2	3				1	1
4-29-78	MR 2	5- 1-78	MR 5	2			3		3
5-19-79	MR 5	6- 3-79	MR 2	15				3	3
5-19-79	MR 2	6- 5-79	MR 2	17					0
6-27-78	MR 2	6-17-79	MR 5	357			3		3
5-29-79	MR 3	6-17-79	MR 3	19					0
5-29-79	MR 3	10- 5-79	MR 39	129			36		36
6-27-78	MR 6	10- 7-79	MR 5	469				1	1
5-12-79	MR 10	10- 7-79	MR 5	148				5	5
10- 7-79	MR 2	4-20-80	CF 307	196	62			2	64
10- 7-79	MR 2	10-10-79	FB 278	3	33			2	35
4-15-77	MR 2	4-27-77	MR 2	12					0
10- 5-79	MR 43	8-19-80	HW 190	319		55		43	98
4-18-77	MR 2	8- 2-77	TJ 2	106		243		2	245
10- 9-79	TR 121	4-20-80	MR 2	194				121	121
				Channel Catfish					
8-11-77	TJ 3	8-10-79	TJ 3	729					0
8-11-77	TJ 3	7- 3-78	MU 2	327		49*	2		51
8-11-77	TJ 3	10-11-78	PK 159	427		162*			162
8-11-77	TJ 3	6-27-78	MU 79	321		49*	79		128

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag			Recapture			Time at	Distance Moved in Missouri River (km)		Distance Moved in Tributary (km)		Total
Date	Location[1/]		Date	Location[1/]		Large (Days)	Upstream	Downstream	Upstream	Downstream	Distance Moved (km)
						Channel Catfish					
8-12-77	TJ	3	6-11-78	MU	119	304		49*	119		168
8-13-77	TJ	3	6-10-78	MU	79	302		49*	79		128
8-13-77	TJ	3	6-24-78	MR	2	316	242		2		244
8-13-77	TJ	3	8- 1-78	MU	87	354		49*	87		136
8-15-77	TJ	3	9-10-79	TJ	16	757	13				13
8-15-77	TJ	3	7- 5-78	JL	156	325	153				153
8-16-77	TJ	3	6-25-78	MU	119	314		49*	119		168
8-16-77	TJ	3	8- 7-78	PK	8	357		11*			11
8-26-77	TJ	3	6-13-78	RB	29	292	26				26
8-26-77	TJ	3	6-24-78	PK	69	303		72*			72
8-26-77	TJ	3	7- 4-79	PK	47	678		50*			50
8-26-77	TJ	3	6-17-79	PK	69	661		72*			72
8-27-77	TJ	3	6-22-78	MR	2	300	242		2		244
8-27-77	TJ	3	6- 4-78	MU	84	282		49*	84		133
8-27-77	TJ	3	7-26-78	MU	35	334		49*	35		84
8-27-77	TJ	3	5-20-78	MU	79	267		49*	79		128
8-27-77	TJ	3	9- 3-79	PK	69	738		72*			72
8-27-77	TJ	3	6-10-79	MU	51	653		49*	51		100
8-28-77	TJ	3	6- 5-79	PK	159	647		162*			162
8-28-77	TJ	3	6- 4-78	MU	40	281		49*	40		89
8-28-77	TJ	3	6-14-78	MU	119	291		49*	119		168
8-28-77	TJ	3	4-18-78	PK	68	234		71*			71
8-28-77	TJ	3	5-13-78	MU	3	259		49*	3		52
8-29-77	TJ	3	6- 6-78	MU	40	282		49*	40		89
8-29-77	TJ	3	5-20-78	RB	37	265	34				34
8-29-77	TJ	3	7-20-78	MU	3	326		49*	3		52
8-29-77	TJ	3	4-13-78	PK	68	228		71*			71
8-30-77	TJ	3	5-29-78	MU	40	273		49*	40		89
8-30-77	TJ	3	6-13-78	RB	34	288	31				31
8-30-77	TJ	3	5-27-78	RB	29	271	26				26

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag Date	Tag Location[1/]	Recapture Date	Recapture Location[1/]	Time at Large (Days)	Distance Moved in Missouri River (km) Upstream	Distance Moved in Missouri River (km) Downstream	Distance Moved in Tributary (km) Upstream	Distance Moved in Tributary (km) Downstream	Total Distance Moved (km)
				Channel Catfish					
7-29-77	JL 132	9- 1-77	JR 3	34	8		3		11
7-29-77	JL 135	8-20-78	CB 206	388	71				71
8-31-78	TJ 3	5-27-79	RB 29	270	26				26
8-31-78	TJ 3	7- 1-79	FB 270	305	267				267
8-31-78	TJ 3	6- 3-79	JL 135	277	132				132
8-31-78	TJ 3	8-10-79	TJ 3	345					0
9- 1-78	TJ 3	6- 9-79	MU 79	282		49*	79		128
9- 1-78	TJ 3	7-14-79	PK 40	317		43*			43
9- 1-78	TJ 3	6-22-79	MU 29	295		49*	29		78
9- 1-78	TJ 3	5-10-80	PK 2	617		5*			5
9- 2-78	TJ 3	7-10-80	TJ 16	677	13				13
9- 2-78	TJ 3	4-10-79	TJ 3	221					0
9- 2-78	TJ 3	5-18-80	PK 40	624		43*			43
9- 2-78	TJ 3	5-10-80	PK 2	616		5*			5
9- 2-78	TJ 3	7- 6-80	MU 27	673		49*	27		76
9- 4-78	TJ 3	8-10-79	TJ 3	341					0
9- 4-78	TJ 3	7-23-79	MU 119	323		49*	119		168
9- 4-78	TJ 3	7-27-79	MU 2	327		49*	2		51
9- 4-78	TJ 3	5-27-79	PK 47	266		50*			50
9- 4-78	TJ 3	6-30-79	MU 119	300		49*	119		168
9- 4-78	TJ 3	9-10-79	TJ 16	372	13				13
9- 4-78	TJ 3	9-10-79	RB 29	372	26				26
9- 4-78	TJ 3	5-10-80	PK 2	614		5*			5
8- 5-78	MR 2	9- 2-78	TJ 3	28		242		2	244
8-12-79	TJ 3	7-10-80	TJ 16	333	13				13
8-14-79	TJ 3	5-24-80	TJ 16	284	13				13
8-24-79	TJ 3	5-20-80	PK 21	270		24*			24
8-27-79	TJ 3	5- 4-80	TJ 13	251	10				10
8-28-79	TJ 3	8-24-80	RB 27	362	24				24
8-29-79	TJ 3	6-21-80	JL 135	297	132				132
8-29-79	TJ 3	7-13-80	CI 64	319	61				61

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag		Recapture		Time at	Distance Moved in Missouri River (km)		Distance Moved in Tributary (km)		Total Distance
Date	Location[1/]	Date	Location[1/]	Large (Days)	Upstream	Downstream	Upstream	Downstream	Moved (km)
				Channel Catfish					
9-10-79	TJ 3	7-19-80	CI 63	314	60				60
				Shovelnose Sturgeon					
9-23-76	LF 241	4-10-77	CF 307	201	66				66
4-27-77	LF 241	6-16-78	MR 3	417	4		3		7
4-27-77	LF 241	7-12-78	MR 2	443	4		2		6
8- 7-78	MR 2	8-16-78	LF 248	9	3			2	5
7-19-77	CB 203	5-24-78	CB 201	310		2			2
8-18-78	CB 195	6-29-79	CB 198	316	3				3
5-24-78	CB 203	7-28-79	CB 224	431	21				21
6-16-77	JL 137	7-28-79	CB 212	774	75				75
7-21-77	JL 135	5-20-80	MR 2	1034	110		2		112
6-14-77	LF 232	8- 3-77	CI 63	50		169			169
9-28-76	JL 137	7- 8-77	RB 37	285		100			100
7-18-77	CB 212	5-10-80	LF 233	1027	21				21
				Blue Suckers					
7-21-78	RB 50	5-19-79	FB 246	303	196				196
6-18-79	LF 259	7-27-79	LF 248	39		11			11
7-30-76	FB 280	7-18-77	CB 212	354		68			68
10- 6-76	RB 37	5-24-78	HW 166	596	129				129
7- 7-77	SF 97	8-21-78	CI 61	411		36			36
7- 1-77	HW 153	5-16-79	CI 84	685		69			69

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag		Recapture		Time at	Distance Moved in Missouri River (km)		Distance Moved in Tributary (km)		Total Distance
Date	Location[1/]	Date	Location[1/]	Large (Days)	Upstream	Downstream	Upstream	Downstream	Moved (km)
				Smallmouth Buffalo					
8-11-79	MD 322	8-12-79	MD 320	1		2			2
8-20-79	MD 312	9-11-79	MD 314	22	2				2
9-12-79	CF 294	9-12-79	FB 288	0		6			6
6-29-77	LF 238	5-23-78	PK 68**	330		306*			306
6-18-77	CI 50	5-20-78	PK 68**	338		118*			118
7- 8-77	CI 66	7-12-77	PK 40**	4		106*			106
				Walleye					
5-11-80	CF 293	6-20-80	PK 69	40		362*			362
3-24-77	FB 280	6- 1-77	FB 280	69					0
9-23-76	LF 241	4-25-80	LF 246	1311	5				5
9-21-76	LF 248	9-23-76	LF 241	2		7			7
7-16-79	CB 201	8- 1-79	LF 233	16	32				32
10- 6-79	MR 19	4-10-80	MR 2	187				17	17
				Northern Pike					
4-27-77	MR 2	12- 5-79	MR 129	954			127		127
4- 7-77	TJ 2	5- 2-79	TJ 5	757			3		3
4-21-77	TJ 3	5- 2-79	MR 129	743	242		129		371
				Burbot					
4- 9-77	MR 2	4-12-77	MR 2	3					0
3-11-77	MR 2	4-15-77	MR 2	35					0
5-23-79	MR 6	4-13-80	MR 2	326				4	4

Table 17. Movement of tagged fish in the middle Missouri River study area during the inventory period from October 1, 1975 through October 1, 1980.

Tag Date	Tag Location1/	Recapture Date	Recapture Location1/	Time at Large (Days)	Distance Moved in Missouri River (km) Upstream	Distance Moved in Missouri River (km) Downstream	Distance Moved in Tributary (km) Upstream	Distance Moved in Tributary (km) Downstream	Total Distance Moved (km)
				Freshwater Drum					
8-12-79	MD 323	9-11-79	MD 322	30		1			1
9-12-79	CF 307	8-13-80	CF 306	337		1			1
				Brown Trout					
8-15-79	MD 315	8-15-79	MD 312	0		3			3
7-18-79	FB 288	3-14-80	MD 333	240	45				45
				Bigmouth Buffalo					
6-13-78	FB 278	8- 4-78	PK 47**	52		325*			325
				Mountain Whitefish					
5-19-79	MR 3	8-10-79	MR 117	83			114		114

1/ Tag and recapture location abbreviations: (1) Missouri River mainstem locations - MD = Morony Dam, CF = Carter Ferry, FB = Fort Benton, LF = Loma Ferry, CB = Coal Banks Landing, HW = Hole-in-the-Wall, JL = Judith Landing, SF = Stafford Ferry, CI = Cow Island, RB = Robinson Bridge and TJ = Turkey Joe (2) Tributary locations - MR = Marias River, TR = Teton River, JR = Judith River and MU = Musselshell River (3) PK = Fort Peck Reservoir

* Distance moved includes a downstream movement in the Missouri River and an eastward movement through Fort Peck Reservoir.

** Fish recaptured and harvested by commercial fishermen in Fort Peck Reservoir.

were made upstream in the spring and summer. Some of the sauger recaptured upstream from Fort Benton had been tagged in the Missouri River near the headwaters of Fort Peck Reservoir. Several of these fish moved upstream for distances of more than 200 km. In summary, the tag return evidence verifies that sauger using the Missouri River upstream from Fort Benton for spawning and feeding come from areas throughout the Missouri between Fort Benton and Fort Peck Reservoir, a distance of approximately 280 km.

Another significant movement pattern for a portion of the sauger residing seasonally in the Missouri River upstream from Fort Benton was their migration downstream in the Missouri River and upstream into the lower Marias River. Eleven sauger tagged in the Missouri River upstream from Fort Benton in July and August were recaptured the following spring in the lower Marias River. These fish moved 35 to 80 km downstream in the Missouri River and then several kilometers upstream in the lower Marias River to spawn. The recaptures were made in the lower Marias River during the spawning period in April and May. Two sauger tagged in the lower Marias River during the spring spawning period were recaptured in the Missouri River upstream from Fort Benton after the spawning period in June and July. These fish moved several kilometers downstream in the Marias River and 35 to 55 km upstream in the Missouri River. Three additional sauger tagged in the lower Marias River were recaptured in the Missouri River between the confluence of the Marias River and Fort Benton. These fish moved several kilometers downstream in the Marias River and 6 to 33 km upstream in the Missouri River to the recapture sites.

Sauger residing in the Missouri River below the confluence of the Marias River also use the Marias for spawning. Three sauger tagged in the Missouri below the Marias prior to the spawning period were recaptured in the lower Marias River during the spawning period. These fish moved 5 to 239 km upstream in the Missouri River and several kilometers upstream in the Marias River. Four sauger tagged in the lower Marias River during the spawning period were recaptured in the Missouri River below the confluence of the Marias River after the spawning period. These fish moved several kilometers downstream in the Marias River and 4 to 243 km downstream in the Missouri.

Tag returns reveal that sauger from the Missouri River which enter the lower Marias River for spawning come from anywhere in the immediate vicinity of the confluence of the Marias River to at least as far as 243 km downstream and 80 km upstream. This evidence indicates that sauger residing throughout the Missouri from Morony Dam to Fort Peck Reservoir use the lower Marias River for spawning. Spawning success of sauger in the lower Marias River has been confirmed by collecting larval sauger in ½-meter plankton nets.

As mentioned previously, electrofishing surveys also indicate that sauger from the Missouri River use the lower Judith and Teton rivers and the Missouri River upstream from Fort Benton for spawning. Larval sauger have not been collected from these sites, but the presence of large numbers of ripe sauger in these areas during the spawning period indicates that they are spawning sites.

In summary, movements of sauger in the middle Missouri River are extensive, and several intricate migration patterns have been identified. The migration patterns include:

1. A sesaonal spawning and feeding migration of sauger from areas in the Missouri River downstream from Fort Benton into the reach of river between Fort Benton and Morony Dam. This is, by far, the most significant migration pattern of sauger. It involves a large portion of the sauger population of the Missouri River from Morony Dam to Fort Peck Reservoir and is probably vital to its survival.

2. A seasonal spawning migration of sauger from areas in the Missouri River above the confluence of the Marias River into the lower Marias River.

3. A seasonal spawning migration of sauger from areas in the Missouri River below the confluence of the Marias River into the lower Marias River.

4. A seasonal spawning migration of sauger from areas in the Missouri and Marias rivers into the lower Teton River.

5. A seasonal spawning migration of sauger from areas in the Missouri River into the lower Judith River.

The latter four movement patterns involve migrations of sauger between the mainstem of the Missouri River and its tributaries. These migrations are collectively significant, and are important in maintaining the sauger population in the mainstem of the middle Missouri River. However, the tributary spawning migrations do not appear to be as important as the mainstem spawning migration into the Missouri River upstream from Fort Benton. The tributary migrations involve smaller numbers of fish, and the migrations appear to be related only to spawning. The mainstem migration involves significantly more fish, and the migration appears to be related to both spawning and feeding.

Channel catfish

Movement data for channel catfish were provided by 66 recaptures of tagged fish in the study area. Ninety-four percent of the recaptured channel catfish moved one kilometer or more from the site where they were tagged. Distances moved by individual fish ranged from 5 to 267 km (Table 17). Other researchers have also reported extensive movements of channel catfish in large rivers. Elser et al. (1977) observed channel catfish movements ranging from 1 to 333 km in the lower Yellowstone and Tongue rivers, Montana. Hubley (1963) reported channel catfish movements of up to 344 km upstream and 275 km downstream in the upper Mississippi River.

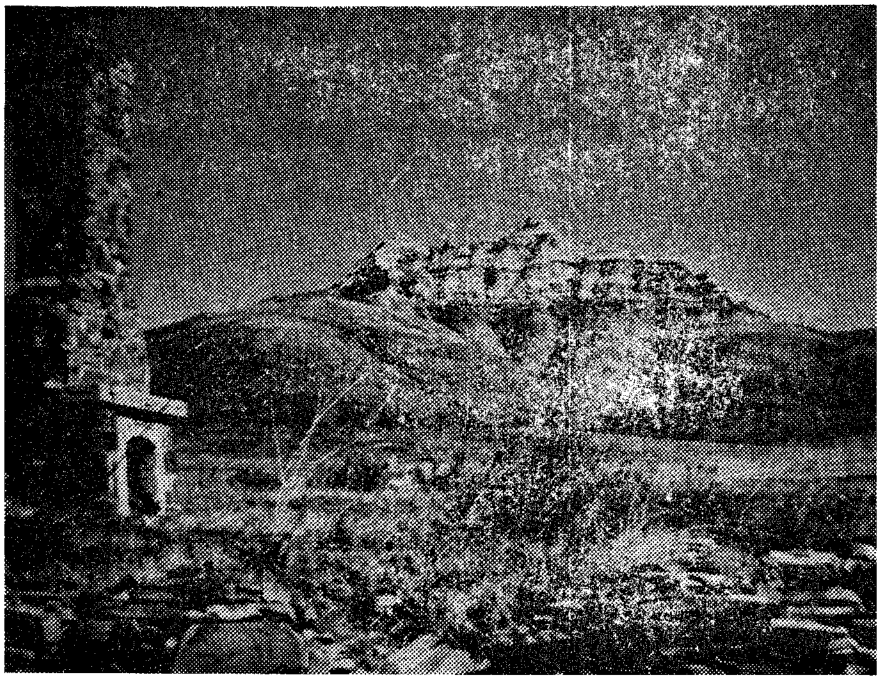
The largest numbers of channel catfish in the Missouri River are found in a 37-km reach of the river between Robinson Bridge and Fort Peck Reservoir. Channel catfish normally residing in this area apparently move long distances during the spawning period. A total of 1792 channel catfish were tagged in the Missouri River at the Turkey Joe study site about 3 km upstream from Fort Peck Reservoir. Most of the fish were tagged at Turkey Joe in August and September following the channel catfish spawning period. Sixty-three channel catfish tagged at Turkey Joe were recaptured in subsequent research surveys or by anglers. Most recaptures were made in succeeding years during the channel catfish migration and spawning period from late May through early August.

Channel catfish recaptured during the migration and spawning period exhibited extensive and divergent movement patterns. Six percent of the catfish tagged at Turkey Joe were recaptured at the release site, 30 percent were recaptured upstream in the mainstem of the Missouri River, 35 percent moved eastward through the headwaters of Fort Peck Reservoir and upstream into the Musselshell River where they were recaptured, 25 percent were recaptured in Fort Peck Reservoir, and 3 percent moved upstream in the Missouri River and were recaptured in the lower Marias River. Since many of the tag returns were provided by anglers, the percentages could reflect some bias if fishing pressure was not equally distributed at the recovery sites. However, observations of anglers made during the study period suggest that fishing pressure was fairly evenly distributed, and bias was probably negligible. Therefore, the recaptured catfish should provide an accurate appraisal of general migration tendencies of the population.

Channel catfish recaptured in the mainstem of the Missouri River upstream from the Turkey Joe study site moved from 10 to 267 km. The fish which moved 267 km was tagged at the Turkey Joe site on August 31, 1978, and was recaptured during the spawning period at Fort Benton, July 1, 1979. Several other channel catfish moved more than 100 km in the mainstem. The data indicate that channel catfish in the Turkey Joe area migrate throughout the Missouri River between Fort Benton and Fort Peck Reservoir.

Another significant movement pattern identified for channel catfish residing at Turkey Joe was a seasonal spawning migration upstream through the Missouri River and into the lower Marias River. One channel catfish tagged at Turkey Joe on August 13, 1977, was recaptured 316 days later on June 24, 1978, in the lower Marias River. Another catfish tagged on August 27, 1977, was recaptured 300 days later on June 22, 1978, in the lower Marias River. Each of these fish moved 242 km upstream from the tag site at Turkey Joe to the confluence of the Marias River, and then 2 km up the Marias River to the recapture site. One channel catfish tagged during the spawning period in the lower Marias River on August 5, 1978, was recaptured at Turkey Joe, September 2, 1978. This fish moved 244 kilometers downstream (2 km in the Marias and 242 in the Missouri) in 28 days. The data indicate that channel catfish using the lower Marias River for spawning come from areas throughout the entire length of the Missouri River downstream from its confluence with the Marias River, a distance of approximately 245 km.

Another significant movement pattern identified for channel catfish residing at Turkey Joe was a seasonal spawning migration eastward through the headwaters of Fort Peck Reservoir and into the lower Musselshell River. Twenty-two channel catfish tagged at Turkey Joe from mid-August through early September were recaptured in subsequent years in the Musselshell River from late May through early August. To spawn, these fish moved 3 km downstream in the Missouri River, 46 km eastward through Fort Peck Reservoir and upstream into the lower Musselshell River. Channel catfish were recaptured in the Musselshell River at distances ranging from 2 to 119 km upstream from the mouth. An irrigation diversion dam on the Musselshell River near the town of Musselshell, 119 km upstream from the mouth, blocks further movement of the migrant channel catfish. Five channel catfish tagged at Turkey Joe were caught immediately below this diversion dam by anglers. These fish each moved a distance of 168 km. Recapture data indicate that channel catfish in the Turkey Joe area migrate to areas of the lower Musselshell River from the diversion dam to the mouth. Weidenheft



(1980) indicated that the peak of channel catfish spawning activity in the lower Musselshell River probably occurs from late May through mid-June. Every effort should be made to keep the lower 119 km of the Musselshell River free from barriers, so the channel catfish spawning migration in this river can continue undiminished.

Sixteen channel catfish tagged at Turkey Joe were recaptured in Fort Peck Reservoir. These fish moved 3 km downstream in the Missouri River and 8 to 159 km eastward through Fort Peck Reservoir to the recovery sites. Fort Peck Reservoir is about 199 km in length from the dam to its confluence with the Missouri River near Turkey Joe. Tag return evidence indicates that channel catfish in the Turkey Joe area migrate into Fort Peck Reservoir at least as far eastward as the mouth of Crooked Creek, a site located 40 km from Fort Peck Dam. Most channel catfish were recaptured in Fort Peck Reservoir following or prior to the spawning period.

Shovelnose Sturgeon

Movement data for shovelnose sturgeon were provided by 12 recaptures of tagged fish in the study area. All of the recaptured fish moved from the site where they were tagged. Distances moved ranged from 3 to 112 km upstream and from 2 to 169 km downstream (Table 17). Other researchers have also reported significant movements of shovelnose sturgeon in rivers. Schmulbach (1974) observed shovelnose sturgeon movements of up to 533.6 km downstream in the lower Missouri River. Christenson (1975) reported shovelnose sturgeon movements of up to 19 km upstream and 17 km downstream in the Red Cedar River, Wisonsin. Helms (1974a) found the maximum distance moved

by shovelnose sturgeon in the upper Mississippi River, Iowa, was 193 km upstream. Moos (1978) reported a shovelnose sturgeon which moved 250 km downstream in the lower Missouri River, South Dakota and Nebraska.

Recaptures of shovelnose sturgeon in the study area provided evidence of the importance of the lower Marias River as a spawning area for shovelnose sturgeon. One shovelnose sturgeon tagged in the Missouri River 4 km below the mouth of the Marias River on April 27, 1977, was recaptured 417 days later on June 16, 1978, during the spawning period in the Marias River 3 km upstream from its confluence with the Missouri. Another shovelnose sturgeon tagged in the Missouri River 4 km below the mouth of the Marias River on April 27, 1977, was recaptured 443 days later on July 12, 1978, in the Marias River, 2 km upstream from the mouth. One shovelnose sturgeon tagged 2 km upstream from the mouth of the Marias River on August 7, 1978, was recaptured nine days later in the Missouri River, 3 km upstream from its confluence with the Marias River. The maximum distance moved by a shovelnose sturgeon using the lower Marias River for spawning was a fish tagged immediately below Judith Landing on July 21, 1977. This fish was recaptured 1034 days later during the spawning period in the lower Marias River, 2 km upstream from the mouth. This fish moved 112 km from the tag site to the recapture site. It appears that shovelnose sturgeon from the Missouri River using the lower Marias River for spawning come from anywhere in the immediate vicinity of the confluence to at least as far as 110 km downstream.

It also appears that shovelnose sturgeon use the Missouri River upstream from Fort Benton for spawning. Electrofishing evidence indicates that shovelnose sturgeon begin to move into this area in mid-April, and numbers peak during the June spawning period. One shovelnose sturgeon tagged in the Missouri River just below the confluence of the Marias River on September 23, 1976, was recaptured April 10, 1977, at Carter Ferry. This fish moved 66 km upstream in 201 days. Presently, there are no barriers in the Missouri River to inhibit any of the shovelnose sturgeon migration routes which have been identified.

Blue Suckers

Electrofishing evidence indicates that blue suckers make extensive seasonal movements in the Missouri River. One blue sucker tagged near Robinson Bridge on July 21, 1978, was recaptured during the spawning period on May 19, 1979, just upstream from Fort Benton, a movement of 196 km upstream (Table 17). One blue sucker tagged near Robinson Bridge on October 6, 1976, was recaptured during the spawning period near Hole-in-the-Wall on May 24, 1978, a movement of 129 km upstream. Electrofishing surveys indicate that blue suckers migrate during the spawning period at least as far upstream as the mouth of Highwood Creek, 320 km upstream from Fort Peck Reservoir.

Smallmouth and Bigmouth Buffalo

Smallmouth and bigmouth buffalo are common and important fish species in the middle Missouri River. They comprise a significant portion of the commercial fishery which exists in Fort Peck Reservoir. Three smallmouth buffalo and one bigmouth buffalo tagged in the middle Missouri River were subsequently recaptured and harvested in Fort Peck Reservoir by commercial fishermen (Table 17). These fish moved for distances which ranged from 106 to 325 km from the tag site to the harvest site.

Electrofishing and tag return evidence indicates that smallmouth and bigmouth buffalo move considerable distances in the Missouri River between Morony Dam and Fort Peck Reservoir, particularly during their spawning periods. One bigmouth buffalo tagged on June 13, 1978, while spawning in a backwater near Fort Benton was harvested 52 days later by commercial fishermen in Fort Peck Reservoir. This fish moved 278 km downstream in the Missouri River and 47 km eastward through Fort Peck Reservoir to the harvest site. One smallmouth buffalo tagged on June 29, 1977, while spawning in a backwater near Loma Ferry was harvested 330 days later by commercial fishermen in Fort Peck Reservoir. This fish moved 238 km downstream in the Missouri River and 68 km eastward through Fort Peck Reservoir to the harvest site. Electrofishing surveys indicate that large numbers of bigmouth and smallmouth buffalo are found seasonally in the Missouri River during the spawning period as far upstream as Horseshoe Falls, 5 km below Morony Dam.

Other Species

Limited information on movements of walleye, northern pike, burbot, freshwater drum, brown trout, and mountain whitefish was provided by recaptures of tagged fish (Table 17). One walleye tagged near Carter Ferry on May 11, 1980, was recaptured 10 days later by an angler in Fort Peck Reservoir. This walleye was a large female which apparently spawned in the Carter Ferry area. The fish moved 293 km downstream in the Missouri River and 69 km eastward through Fort Peck Reservoir to the harvest site. Electrofishing data indicate walleye spawn in the Missouri River at least as far upstream as Horseshoe Falls, 5 km below Morony Dam. Most walleye found in the Missouri River are probably seasonal migrants from Fort Peck Reservoir.

One northern pike tagged 3 km upstream from Fort Peck Reservoir on April 21, 1977, was recaptured in the Marias River below Tiber Dam on May 2, 1979. This movement of 371 km was the greatest distance moved by any tagged fish in the study area during the inventory period. Another northern pike tagged near the mouth of the Marias River on April 27, 1977, was recaptured on December 5, 1979, in the Marias River at Tiber Dam, a movement of 127 km. Many of the northern pike in the Missouri River are probably seasonal migrants from Fort Peck Reservoir. Northern pike are found seasonally in the Missouri River as far upstream as the Big Eddy, 7 km below Morony Dam.

Discussion

Migration patterns of numerous fish species have been identified in the middle Missouri River and its tributaries. Presently, there are no barriers in the mainstem of the Missouri River between Morony Dam and Fort Peck Reservoir to block any of the migration routes which have been

identified. The migration routes are undoubtedly important to the survival of several fish species which inhabit Fort Peck Reservoir, the Missouri River, and its tributaries. Every effort must be made to keep the Missouri River free from barriers so the spawning, feeding, and other migration movements can continue undiminished.

Marias River Spawning Migrations

The lower 4 km of the Marias River was sampled regularly by electrofishing during the spring/summer of 1976, 1977, 1978, and 1979 to monitor spawning runs of fish from the Missouri River. In addition, frame traps were operated in the lower 2 km of the Marias River during the spawning periods in 1976, 1977 and 1978, and baited hoop nets were used in the same reach in 1978 and 1979. Electrofishing was generally effective to monitor migrations of all species in the Marias River except channel catfish. Frame traps were mostly selective for sauger and walleye, and baited hoop nets were almost exclusively selective for channel catfish.

The lower Marias River was sampled prior to and following the spawning runs to determine the size and abundance of resident fish species. Fish captured in the lower Marias River during the spawning season were assumed to be from the Missouri River if they were in a ripe spawning condition and obviously overabundant for the habitat present. Also, some fish captured in the lower Marias River had tags attached from fish population study sections on the mainstem of the Missouri River, which confirmed their origin.

Sampling efforts on the lower Marias River during the spring/summer migration periods were limited. Since only selected days during the migration periods were sampled, spawning numbers presented in this report represent only a portion of the runs and do not necessarily reflect their magnitude. Also, the study section surveyed on the lower Marias represents only a small portion of the total spawning area available. Significant numbers of migrant fish move upstream in the Marias River to spawning areas located upstream from the study section. Evidence of this was provided by angler tag returns and by limited sampling conducted in the upstream areas.

The game fish species which most heavily used the lower Marias River for spawning were sauger, shovelnose sturgeon, and channel catfish. River carpsucker, shorthead redhorse, longnose sucker, and goldeye were the most abundant nongame spawning migrants found in the lower Marias. Migrant blue suckers and bigmouth and smallmouth buffalo also made significant use of the lower Marias River for spawning, but they were less abundant than the preceding nongame species. Results of electrofishing, frame trapping, and baited hoop netting surveys conducted on the lower Marias River during the spring/summer spawning migration periods from 1976 through 1979 are presented in Appendix Tables 53, 54, and 55.

Sauger and Shovelnose Sturgeon

The relation of water temperature and discharge to sauger and shovelnose sturgeon spawning in the lower Marias River during each of the four survey years is shown in Figure 22. The spawning periods shown on the graph were defined as the time between the first observation of a spent or partly spent female to the last observation of a ripe female. The peak of spawning was judged by a combination of a large number of spawning migrants and a high percentage of ripe females among the migrants. Abnormal flow, water temperature, or ice conditions altered sauger and shovelnose sturgeon

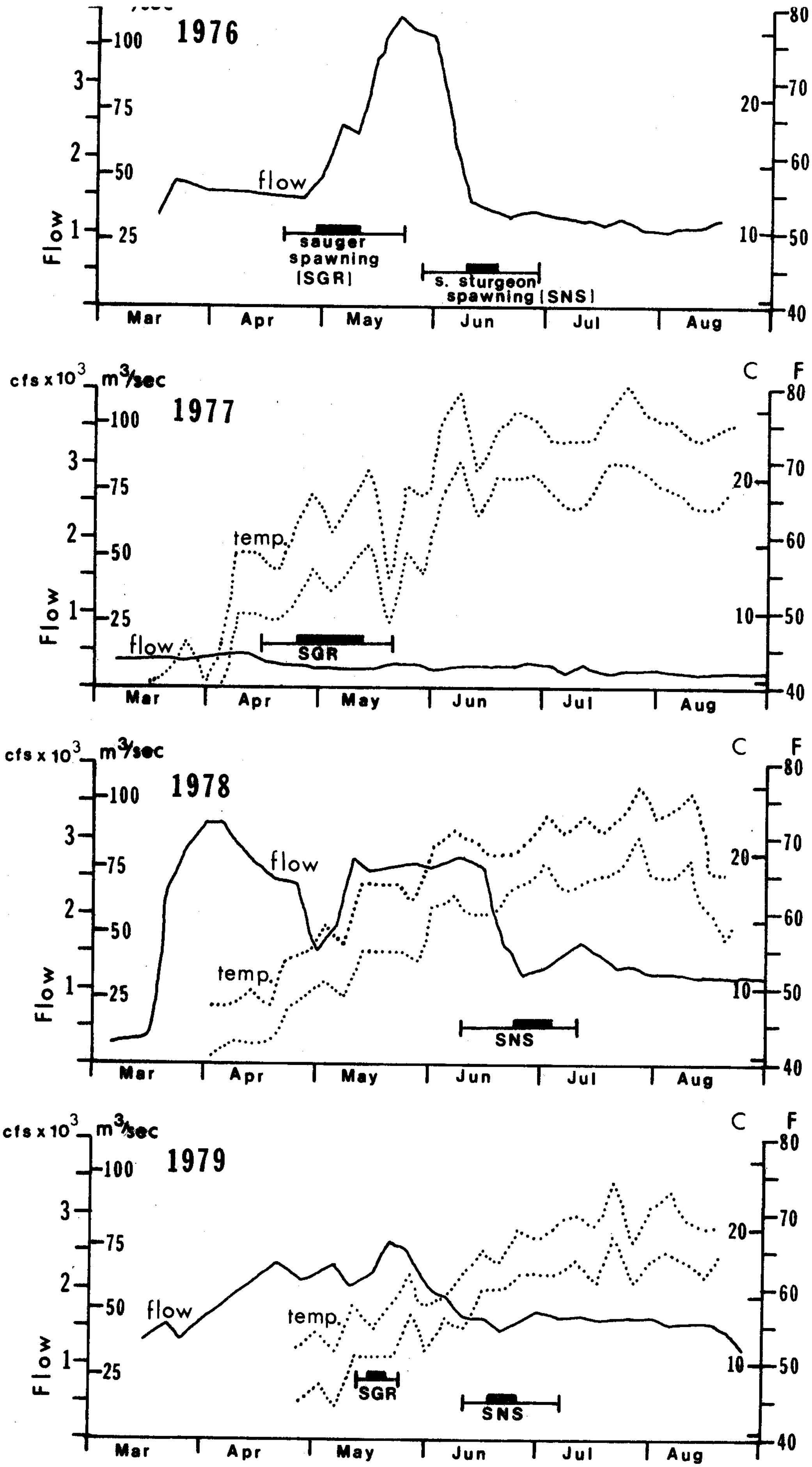


Figure 22. Relation of water temperature and discharge to spawning of sauger and shovelnose sturgeon in the lower Marias River from 1976 through 1979.

spawning in each year except 1976.

In 1976, the magnitude of flow in the lower Marias River during the spring/summer migration period was near normal. However, the runoff peaked slightly sooner than normal in mid-May rather than early June. Water temperature was not measured continuously, but spot measurements revealed near average temperature conditions. The sauger spawning period extended from April 20 to May 22 and peaked from April 29 to May 10. The shovelnose sturgeon spawning period extended from May 27 to June 28 and peaked from June 9 to 17. Since flow, water temperature, and other physical conditions were near normal during the spring/summer period in 1976, the observed spawning periods and peaks should also be considered as typical for the lower Marias River.

In 1977, water temperature in the lower Marias during the spring/summer period was significantly higher than normal, and flow was considerably below normal. As a result of the above normal water temperature, sauger spawning in 1977 occurred slightly earlier than normal. Partly spent female sauger were sampled on April 15, the earliest spawning date observed during the four-year inventory period. The sauger spawning period in 1977 extended from April 15 to May 20 and peaked from April 25 to May 12. Migrant sauger in the lower Marias River were significantly less abundant in 1977 than 1976. In 1976, an average of 1.00 sauger per trap-day was sampled in frame traps during the migration period compared to 0.48 sauger per trap-day in 1977.

The shovelnose sturgeon spawning run in 1977 was even more severely depressed than the sauger run. An average of 15.0 shovelnose sturgeon per electrofishing-kilometer was sampled in 1976 during the peak of the spawning run compared to only 2.3 shovelnose sturgeon per electrofishing-kilometer in 1977. Flow in the lower Marias River in 1977 during the sauger and shovelnose sturgeon spawning periods ranged from 7.9 to 11.3 m^3/sec (280 to 400 cfs), and was obviously well below the minimum flow required to sustain good spawning runs.

In 1978, flow and water temperatures of the lower Marias River during the spring/summer period were near normal. However, a more severe than normal ice break up occurred in the Missouri River in March, 1978. As a result, it appeared that many fish in the Missouri River were displaced downstream into the lower portion of the river or Fort Peck Reservoir. Consequently, the sauger run in the lower Marias River was severely reduced in 1978. An average of only 0.02 sauger per trap-day was sampled during the migration period. However, 11 sauger larvae were sampled with a plankton net on the lower Marias River on June 1 and 2, 1978, indicating that some successful reproduction did occur. Assuming an incubation period of 13 to 21 days as described by Nelson (1968), spawning occurred between May 11 and 20.

Shovelnose sturgeon spawning in the lower Marias River in 1978 occurred significantly later than normal. This may have been the result of substantial downstream displacement of shovelnose related to the severe ice break up, and the long distance of the migration route back upstream to the Marias River. The sturgeon spawning period in the lower Marias River extended from June 9 to July 10 and peaked from June 23 to July 3. An average of 6.3 shovelnose sturgeon per electrofishing-kilometer were sampled during the peak of the spawning run. Two shovelnose sturgeon pro-larvae were sampled with a plankton net on the lower Marias River on June

19, 1978. Assuming an incubation period of one week as estimated by Brown (1971), spawning occurred about June 12.

Severe ice break ups such as the one observed in 1978 occur periodically. It is significant to note that even though this ice break up resulted in substantial downstream displacement of fish, native resident species, such as the shovelnose sturgeon and sauger, were able to move back upstream and spawn successfully in the lower Marias River.

In 1979, flow in the lower Marias River during the spring/summer migration period was near normal, but water temperature was significantly below normal. The cooler-than-average water temperature was due to large amounts of cold water being released from Tiber Reservoir. As a result of the depressed water temperature, sauger and shovelnose sturgeon spawning occurred later than usual. The sauger spawning period extended from May 12 to May 23 and peaked from May 12 to 19. A larval sauger was sampled with a plankton net on the lower Marias River on May 28, 1979. Assuming an incubation period of 13 to 21 days as described by Nelson (1968), spawning occurred between May 7 and 15. The shovelnose sturgeon spawning period in 1979 extended from June 10 to July 6 and peaked from June 17 to 21. An average of 12.7 shovelnose sturgeon per electrofishing-kilometer were sampled during the peak of the spawning run.

The inception of sauger spawning on the lower Marias River in 1977 occurred when mean water temperature reached 11.7 C (53 F). In 1978 and 1979 initial spawning was observed at 12.2 C (54 F). Elser et al. (1977) reported sauger spawning on the Lower Tongue River, Montana, in a temperature range of 9.4 to 12.2 C (49 to 54 F). Peterman and Haddix (1975) observed sauger spawning on the mainstem of the lower Yellowstone between May 16 and 24, 1974, when water temperatures were 7.2 to 11.1 C (45 to 52 F). Brown (1971) indicated sauger spawning usually occurs in Montana when water temperatures reach about 10.0 C (50 F).

Shovelnose sturgeon spawning in the lower Marias River was observed at mean water temperatures ranging from 15.0 to 22.8 C (59 to 73 F), but peak spawning occurred at 16.1 to 20.6 C (61 to 69 F). The optimum temperature range for spawning of shovelnose sturgeon on the lower Tongue River, Montana, was 17.2 to 21.7 C (63 to 71 F) (Elser et al. 1977). In the Powder River, Montana, the peak of the shovelnose sturgeon run occurred at 16.1 C (61 F); however, these fish were not considered ripe (Rehwinkel et al. 1976). Christenson (1975) reported shovelnose sturgeon spawning in the Red Cedar River, Wisconsin, at temperatures between 19.4 and 21.1 C (67 and 70 F). Brown (1971) stated that shovelnose sturgeon usually spawn in Montana at temperatures between 15.6 and 21.1 C (60 and 70 F).

Size at Maturity

Sauger found in the lower Marias River during the migration period were usually mature at sizes larger than 270 to 280 mm (10.6 to 11.0 in.). The smallest mature sauger sampled on the lower Marias River was a 259 mm ripe male. However, most sauger smaller than 270 mm were immature. Female sauger appeared to reach maturity at about the same size as males. The smallest mature female sauger sampled on the lower Marias River was a 274 mm specimen. Brown (1971) indicated that sauger reach maturity at lengths of 229 to 305 mm.

Male shovelnose sturgeon found in the lower Marias River during the migration period were usually mature at a smaller size than females. The minimum fork lengths of ripe male and female sturgeon sampled in the lower Marias during the inventory period were 546 and 709 mm (21.5 and 27.9 in.), respectively. Elser et al. (1977) reported minimum lengths of ripe male and female shovelnose on the lower Tongue River of 523 and 688 mm (20.6 and 27.1 in.), respectively. Other researchers have also reported male shovelnose maturing at a smaller size than females (Christenson 1975, Helms 1974, Monson and Greenbank 1947, Barnickol and Starrett 1951).

Size-Frequency Distributions

The length-frequency distribution of shovelnose sturgeon sampled during the spawning period in the lower Marias River was compared to the length-frequency distribution of shovelnose sturgeon sampled during the spawning and nonspawning periods in the mainstem of the middle Missouri River (Figure 23). The average size of shovelnose sturgeon sampled in the lower Marias River was significantly larger than the average size of sturgeon collected from the Missouri River mainstem. Also, the length distribution was wider for the Missouri River sample than for the Marias River sample. Sturgeon smaller than 550 mm, which are usually immature, were rarely found in the Marias River but were common in the Missouri River mainstem. These data indicate that the lower Marias River shovelnose sturgeon were a migrant spawning population. Peterman and Haddix (1975) and Rehwinkel et al. (1976) found migrant populations of shovelnose sturgeon from the lower Yellowstone River spawning in the lower Tongue and Powder rivers, respectively. The average size of sturgeon found in the tributaries was larger than the average size of sturgeon sampled in the mainstem of the Yellowstone. This was attributed to the tributary sturgeon being spawning populations.

The length-frequency distribution of shovelnose sturgeon sampled in the middle Missouri and Marias rivers was also compared to the length-frequency distribution of shovelnose sturgeon sampled in the Missouri River in South Dakota (Moos 1978), the Mississippi River in Iowa (Helms 1973), and the Chippewa River in Wisconsin (Christenson 1975) (Figure 23). Shovelnose sturgeon in the middle Missouri/Marias River study area were significantly larger than those sampled in the other rivers. In fact, the mean fork lengths of shovelnose sturgeon sampled in the middle Missouri and Marias rivers were about equivalent to the maximum fork lengths attained in the abovementioned study areas.

The weight-frequency distribution of migrant shovelnose sturgeon sampled in the lower Marias River during this study was very similar to the weight-frequency distribution reported for migrant shovelnose sturgeon in the lower Tongue River, Montana (Peterman and Haddix 1974, Elser et al. 1977) (Figure 24). Of the shovelnose sturgeon sampled during the spawning period on the lower Tongue River in 1975 and 1976, 22.6 percent exceeded 2.7 kg (6 lb), 7.2 percent exceeded 3.6 kg (8 lb), and 1.7 percent exceeded 4.5 kg (10 lb). On the lower Marias River from 1976 through 1979, 29 percent of the shovelnose sturgeon sampled during the spawning period exceeded 2.7 kg, 8 percent exceeded 3.6 kg, and 2 percent exceeded 4.5 kg. The average size of sturgeon sampled on the Marias River was 2.43 kg (5.36 lb) compared to 2.41 kg (5.31 lb) on the Tongue River. A sample of shovelnose sturgeon migrating from the Yellowstone River into the lower Powder River, Montana, averaged 2.42 kg (5.33 lb) (Rehwinkel et al. 1976).

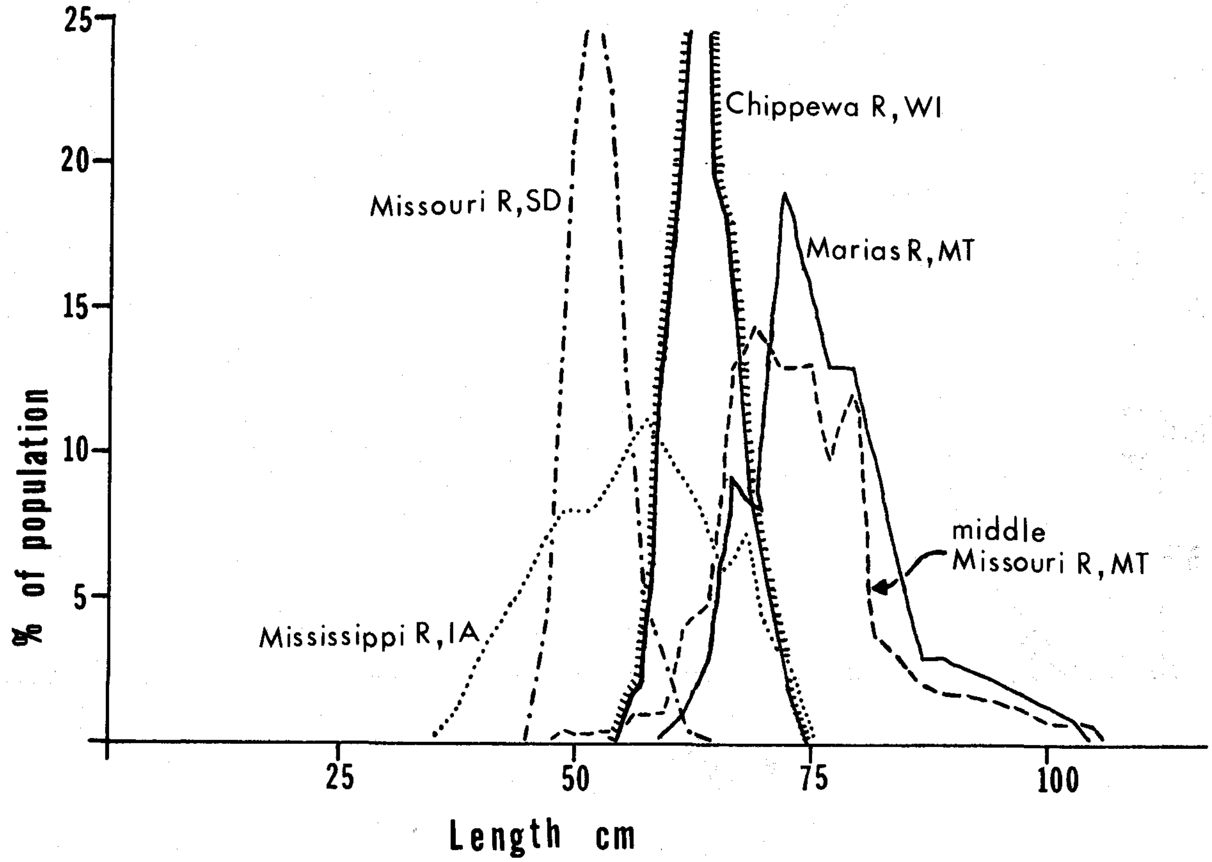


Figure 23. A comparison of the length-frequency distributions of shovelnose sturgeon sampled in the lower Marias and middle Missouri rivers (Montana), Chippewa River (Wisconsin), Mississippi River (Iowa), and Missouri River (South Dakota).

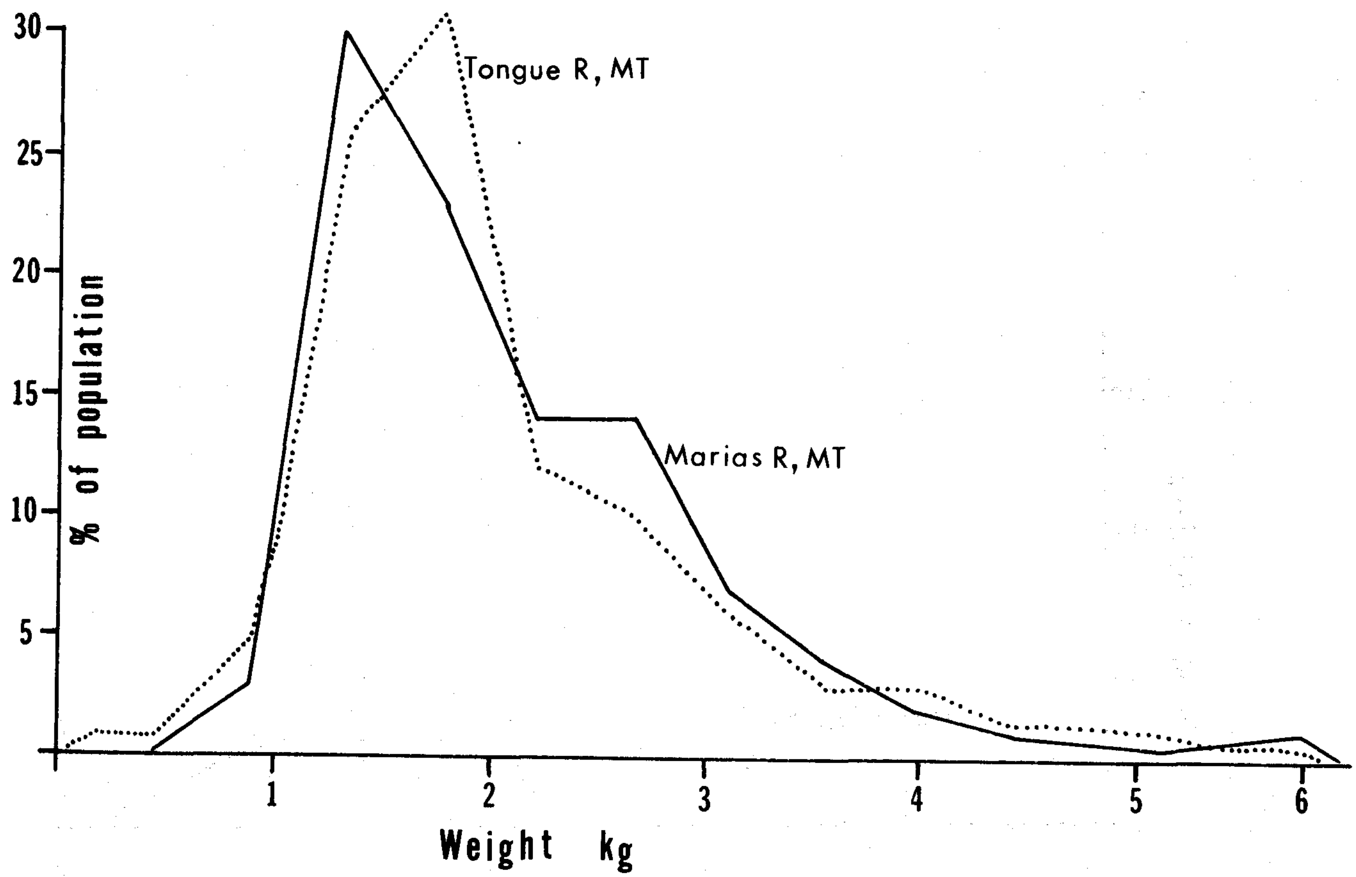


Figure 24. A comparison of the weight-frequency distributions of shovelnose sturgeon sampled in the lower Marias and Tongue rivers, Montana.

Shovelnose sturgeon captured during the spawning period in the lower Marias, Tongue, and Powder rivers, Montana, were considerably larger in both length and weight than those reported in other streams. Even though the sturgeon sampled in the Montana streams were spawning populations, the presence of considerable numbers of larger fish is significant. Carlander (1969) reviewed numerous research reports on shovelnose sturgeon. The largest shovelnose sturgeon recorded in the studies which he reviewed was a 4.536 kg (10 lb) specimen reported by Trautman (1957). Eddy and Surber (1943), Pflieger (1975), and Brown (1971) indicate that shovelnose sturgeon rarely exceed 2.3 to 3.2 kg (5 to 7 lbs).

The relatively large size attained by shovelnose sturgeon in the lower Marias, Tongue, and Powder rivers may be related to an abundant food supply available to these fish in the lower Yellowstone and middle Missouri rivers during the summer months. Two mayflies, *Rhithrogena* and *Traverella*, comprised 58 percent of the food volume in the summer diet of shovelnose sturgeon in the middle Missouri River (Gardner and Berg 1981). *Traverella* are also abundant in the lower Yellowstone River (Newell 1976). They accounted for 46 percent of the food volume in the diet of shovelnose sturgeon in the lower Yellowstone from July to September (Elser et al. 1977). *Rhithrogena* and *Traverella* exhibit relatively little tolerance to habitat changes, and the middle Missouri and lower Yellowstone rivers are the only significant reaches of large river habitat in the Mississippi/Missouri River drainage which have not been extensively altered. Limited findings by researchers studying the food habits of shovelnose sturgeon in other portions of the Mississippi and Missouri rivers indicate that the bulk of the diet is usually comprised of trueflies (Diptera) and caddisflies (Pflieger 1975). The relative scarcity of mayflies in the summer diet of shovelnose sturgeon in these areas could account for the smaller sizes, but this hypothesis requires more supporting evidence.

Shovelnose sturgeon in the middle Missouri and lower Yellowstone rivers may also be a distinct genetic subgroup, and this could explain their larger size. However, genetic studies conducted on shovelnose sturgeon collected in Montana and other states in 1979 failed to confirm this hypothesis (Larry Peterman, DFWP, personal communication).

Channel Catfish and Other Species

Use of the lower Marias River for spawning by migrant channel catfish was studied in 1978 and 1979. An average of 1.06 channel catfish per net-day was captured in 18 net-days on the lower Marias River from August 3 through 9, 1978. By mid-September, spawning was apparently completed, and no channel catfish were taken in 12 net-days of sampling, September 23 through 29, 1978. One channel catfish aelvin was sampled in a plankton net on the lower Marias River on June 19, and three were collected on July 28, 1978. Assuming an incubation period of 6 to 10 days and aelvin dispersal after about five days (Brown 1971), spawning occurred between June 4 and July 17. An average of 2.25 channel catfish per net-day were captured in four net-days on the lower Marias River from June 8 through 12, 1979. These data suggest that peak abundance of migrant channel catfish in the lower Marias River occurs during the early portion of the spawning period.

Maximum water temperature in the lower Marias River during the channel catfish spawning periods in 1978 and 1979 ranged from 18.9 to 25.6 C (66 to 78 F) and averaged 22.2 C (71.9 F). Brown (1971) indicated

channel catfish spawning usually occurs from May into July after water temperatures exceed 23.9 C (75 F). However, Helms (1975) reported spawning activity of channel catfish in the upper Mississippi River, Iowa, usually began in mid-May at a water temperature of 18.3 C (65 F). Initial spawning of channel catfish in the lower Marias River appears to occur when the maximum water temperature reaches 18.9 C (66 F).

Significant spawning runs of blue sucker, smallmouth and bigmouth buffalo, river carpsucker, shorthead redhorse, longnose sucker, and goldeye were observed in the lower Marias River during the spring/summer migration periods from 1976 through 1979. Limited numbers of walleye, northern pike, carp, and several minnow species were also observed spawning in the lower Marias River during the study period. Spawning condition of fish examined during the surveys is shown in Table 18. In general, Catostominae (suckers and redhorse) and goldeye spawned primarily in May, while (Ictiobinae/Cyprinidae (river carpsucker, buffalo and minnows) spawned primarily in June.

Table 18. Spawning condition of several fish species sampled in the lower Marias River during the spring/summer spawning periods from 1976 through 1979.

Fish Species	Range of dates for capture of: Ripe Males	Ripe Females1/	Spent Females2/
Goldeye	May 9-June 9	May 16-June 9	May 16
Northern pike	April 9-May 27		
Carp	May 1-10		
Flathead chub	June 7-July 18	May 24-June 27	June 2
Emerald shiner		June 21	
W. silvery minnow	June 7	June 21	
Longnose dace	May 10-June 7	June 23	July 3
River carpsucker	May 10-July 10	May 24-June 9	
Blue sucker	May 12-June 28	May 29-June 17	May 29
Smallmouth buffalo	May 9-July 3	June 9-21	June 9
Bigmouth buffalo	May 9-July 3	May 29-June 17	May 29
Shorthead redhorse	May 10-June 9	May 10-June 9	
Longnose sucker	June 9	May 10-June 9	
Walleye	April 9-15		

1/ Range of dates for sampling ripe females is equivalent to observed spawning period.

2/ Earliest date observed.

Teton and Judith River Spawning Migrations

The lower several kilometers of the Teton and Judith rivers were sampled on several occasions during the spring/summer migration periods in 1977, 1978, and 1979 to document possible spawning runs from the Missouri River. Considerably less effort was spent on migrant fish surveys in the lower Teton and Judith rivers than on the lower Marias River. Therefore, the spawning runs found in these areas are probably an underestimate of actual use. Further surveys should be conducted to confirm the presence of spawning runs of additional species.

The lower Teton River was sampled by electrofishing on April 27, 1977, and May 13, 1979. A significant number of migrant sauger were found in the lower Teton River. An average of 10.5 sauger per electrofishing-kilometer were sampled on April 27, and 1.5 per electrofishing-kilometer were captured on May 13. This information suggests that peak spawning of sauger in the lower Teton occurs in late April. Sauger spawning on the lower Teton apparently occurs slightly earlier than on the lower Marias. This is probably due to warmer spring water temperatures on the lower Teton River. Sauger found spawning in the lower Teton were significantly less abundant than in the lower Marias.

Numerous migrant goldeye, shorthead redhorse, and longnose suckers were collected on both sampling dates on the lower Teton River, and the fish were in a ripe spawning condition. A few migrant carp were also sampled on both dates, but they were not ripe.

A significant spawning run of blue suckers was observed in the lower Teton River on May 13, 1979. An average of 25.0 blue suckers per electrofishing-kilometer were sampled, and all were ripe males and females or gravid females. Most of the blue suckers were found in the lower 2 kilometers of the Teton River, and the run was confined to the lower 15 km of the river. This run was substantially larger than blue sucker spawning runs observed in the lower Marias River. No blue suckers were found in the lower Teton River in an electrofishing survey conducted on April 27, 1977, indicating that the run probably does not begin until mid-May.

Migrant river carpsucker, smallmouth buffalo, and bigmouth buffalo were conspicuously absent from electrofishing surveys conducted in the lower Teton River. These species usually spawn in larger streams with backwater areas (Brown 1971), and therefore, it is unlikely they spawn in the lower Teton River. As described earlier, significant spawning runs of these three species were found in the lower Marias River. The lower Marias is a substantially larger stream than the lower Teton River, and it contains more slow-moving and backwater areas.

Migrant channel catfish were sampled in the lower Teton River with baited hoop nets in 1978 and 1979. An average of 0.67 channel catfish per net-day were captured in six net-days on the lower Teton River from August 3 through 9, 1978. By mid-September spawning was apparently completed, and no channel catfish were taken in six net-days of sampling from September 23 through 29, 1978. An average of 1.88 channel catfish per net-day were captured in eight net-days on the lower Teton River from June 8 through 12, 1979. Thus, migrant channel catfish are found in the lower Teton River from at least early June through early August.

Largely because of irrigation withdrawals, it is not uncommon for the

lower 20 to 30 km of the Teton River to be dewatered by late August to the extent that only large pools remain. In some years, the lower Teton is completely dewatered. Therefore, the spawning fish found there during the spring/summer migration (runoff) period are all migrants.

The lower Judith River was sampled by electrofishing on May 25 and August 13, 1979. A significant number of mature sauger were sampled on May 25. All female sauger were spent, indicating that spawning was completed prior to May 25. Some of the sauger appeared to be migrants from the mainstem of the Missouri River. The recapture of one sauger previously tagged on the mainstem of the Missouri River confirmed this observation.

Shorthead redhorse and longnose suckers in a ripe spawning condition were abundant in the lower Judith River on May 25, 1979. Many were probably spawning migrants from the Missouri River. A few carp and goldeye were also sampled on the lower Judith on May 25, and some of them were ripe. Two ripe male blue suckers were sampled on May 25, and one spent male was taken on August 13. River carpsucker, smallmouth buffalo, and bigmouth buffalo were conspicuously absent.

No effort was made to sample migrant channel catfish in the lower Judith River with baited hoop nets. However, circumstantial evidence indicates that this river is an important spawning tributary for this species. Gardner and Berg (1981) collected 30 channel catfish aelvins in a plankton net fished in the lower Judith River on August 2, 1979. In addition, numerous logs and other instream cover features necessary for catfish nests are found in the lower Judith.

Age and Growth

Paddlefish

Age Structure of the Population

In 1977 and 1978, 132 paddlefish harvested by anglers from the middle Missouri River were assigned ages ranging from 6 to 29 years (Table 19). The sample included 69 males and 63 females. Males averaged 13.7 years of age and ranged in age from 6 to 25 years. Females averaged 18.7 years and ranged from 11 to 29 years. Forty-four percent of the female paddlefish were 20 years or older, while only 7 percent of the males were this old.

The middle Missouri River paddlefish population is older and probably more stable than most other paddlefish populations in northern waters. In a study of paddlefish in the lower Yellowstone River, Montana, Rehwinkel (1975) found only 0.2 and 3.9 percent of males and females, respectively, were 20 years or older. Twenty-six percent of the paddlefish (male and female combined) harvested by anglers in the Missouri River below Fort Randall Dam, South Dakota, in 1979 were 20 years or older (Unkenholz 1980b). The oldest paddlefish harvested by anglers in the Missouri River below Gavins Point Dam, South Dakota, in 1979 was a 14-year old specimen (Unkenholz 1980a). In 1960, 2.3 percent of the paddlefish collected from the Mississippi River, Iowa, were 20 years or older (Meyer 1960).

Most paddlefish populations in the United States are harvested more intensively by anglers than the middle Missouri population. Since anglers select for larger fish, the older paddlefish experience greater harvest rates than younger fish as fishing pressure increases. The relatively

small harvest rate of paddlefish in the middle Missouri River probably accounts, in part, for the large percentage of old fish.

Table 19. Age structure and observed growth of male and female paddlefish sampled in the middle Missouri River in 1977 and 1978. The number of fish sampled is shown in parentheses.

	Mean Total Length (cm) of Paddlefish in Age Group					
	1977		1978		Combined Average	
Age Group	Male	Female	Male	Female	Male	Female
6			102(1)		102(1)	
7	122(1)				122(1)	
8	132(1)		135(1)		134(2)	
9	136(2)		137(1)		136(3)	
10			137(1)		137(1)	
11	139(5)	156(1)			139(5)	156(1)
12	143(11)		140(4)		142(15)	
13	144(5)	156(4)	142(3)		143(8)	156(4)
14	147(6)	164(3)	142(2)	168(2)	145(8)	166(5)
15	148(6)		144(2)	170(6)	147(8)	170(6)
16	149(4)	169(1)	149(3)		149(7)	169(1)
17		168(5)	150(1)	175(1)	150(1)	170(6)
18	149(2)	168(3)		173(1)	149(2)	170(4)
19	150(2)	169(7)		175(1)	150(2)	171(8)
20	149(3)	171(6)		173(1)	149(3)	171(7)
21	155(1)	171(8)			155(1)	171(8)
22		174(4)				174(4)
23		173(5)				173(5)
24		177(1)				177(1)
25	160(1)			180(1)	160(1)	180(1)
26						181(1)
27		181(1)				
28						
29		188(1)				188(1)

Observed Growth

Since the middle Missouri River paddlefish population is comprised almost entirely of mature, spawning fish, observed annual increments of growth are fairly small (Table 19). Female paddlefish were consistently larger than male paddlefish at all comparable ages. The largest (and oldest) male paddlefish collected for age determination was a 160 cm, 28.6 kg (62.8 in., 63 lb) 25-year-old. The largest (and oldest) female was a 188 cm, 54.8 kg (74.0 in., 121 lb) 29-year-old. The smallest (and youngest) male was a 6-year-old measuring 102 cm (40.0 in.) in total length and weighing 7.7 kg (17 lb). The smallest (and youngest) female was a 156 cm, 22.2 kg (61.3 in., 49 lb) 11-year-old.

Observed growth of paddlefish collected from the middle Missouri River is compared to observed growth in other waters in Table 20. Growth of paddlefish in the middle Missouri River is superior to growth in the other waters at all ages. Growth of paddlefish in the middle Missouri River also exceeds growth in all the studies summarized by Carlander (1969). Based on this evidence, it can be concluded that growth of paddlefish in the middle Missouri River and Fort Peck Reservoir is better than in any other known water in the United States.

Shovelnose Sturgeon

Characteristics of the Annuli

Annuli appearing on the anterior pectoral fin ray sections of shovelnose sturgeon occurred in belts (Figure 25). Four to eight single annuli preceded the first sub-marginal annuli belt. Sub-marginal annuli belts contained from two to three annuli. Zweiacker (1967) identifed similar annuli belt patterns on shovelnose sturgeon pectoral rays from the Missouri River in South Dakota. Roussow (1957) found annuli belts on pectoral fin ray sections of lake sturgeon. These researchers attributed the belts of annuli to slowed growth during periods of gonadal development.

Single annuli occurring on the sections were more widely spaced than annuli within belts, indicating faster growth of the shovelnose sturgeon in the first years of life before belting of annuli occurred. Belting of annuli probably coincided with attainment of sexual maturity and slowed growth due to channeling energies into gonadal development. Spaces also occurred between each sub-marginal annuli belt, probably indicating faster growth between periods of gonadal development.

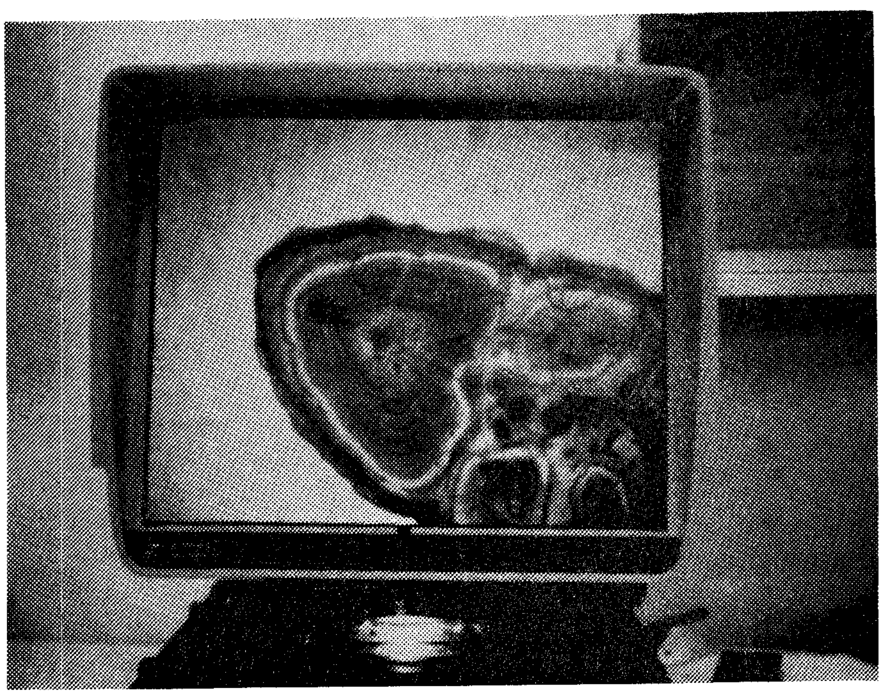


Figure 25. Cross-sections of the anterior pectoral fin rays of shovelnose sturgeon were studied for age and growth determination. The belt patterns of the annuli are probably related to slowed growth during periods of gonadal development.

Table 20. Observed growth of paddlefish sampled from the middle Missouri River in 1977 and 1978 compared to observed growth in other waters. Mean lengths are an average for male and female paddlefish combined, unless otherwise noted. The number of fish sampled is shown in parentheses.

	Mean Total Length (cm) of Paddlefish in Age Group				
Age Group	Middle Missouri R. Montana (present study)	Lower Yellowstone R. Montana (Rehwinkel 1975)	Missouri R., S. Dak. Below Gavins Pt. Dam (Unkenholz 1980a)	Missouri R., S. Dak. Below Ft. Randall Dam (Unkenholz 1980b)	Mississippi R. Iowa (Meyer 1960)
6	102 (1)*		74 (10)		97 (74)
7	122 (1)*		76 (14)		101 (24)
8	134 (1)*		101 (7)		102 (19)
9	136 (3)*	116 (7)*	77 (8)		107 (12)
10	137 (1)*	124 (31)*		99 (1)	109 (9)
11	148 (6)	126 (143)*	92 (3)	89 (1)	111 (10)
12	149 (15)**	129 (135)*	93 (2)	109 (1)	115 (9)
13	150 (12)	135 (92)*		110 (1)	117 (6)
14	156 (13)	140 (48)*	? (1)	116 (2)	120 (5)
15	159 (14)	144 (43)		114 (1)	122 (5)
16	159 (8)	147 (86)		102 (1)	122 (1)
17	160 (7)	147 (199)		112 (4)	
18	160 (6)	149 (163)			
19	161 (10)	151 (108)		115 (2)	130 (2)
20	160 (10)	151 (21)		117 (1)	131 (2)
21	163 (9)			114 (4)	
22	166 (4)**				138 (2)
23	165 (5)**				
24	167 (1)**				
25	170 (2)				
26	171 (1)**	151 (1)			
27	171 (1)**				
28					
29	178 (1)**				

* Mean length of male paddlefish only, ** mean length calculated by interpolating size of opposite sex

If the interpretation of the single annuli/annuli belt patterns is correct, shovelnose sturgeon in the middle Missouri River become sexually mature at 4 to 8 years and make their first spawning attempt between 6 and 11 years. They spawn every 2 to 3 years after their initial attempt.

Assigned Ages and Observed Growth

In 1978 and 1979, 122 shovelnose sturgeon sampled on the middle Missouri River were assigned ages ranging from 8 to 33 years and averaging 21.3 years (Table 21). Ninety-three percent of the sturgeon in the sample were 15 years or older. Zweiacker (1967) reported shovelnose sturgeon in the Missouri River in South Dakota ranged from 8 to 27 years, and 80 percent of the sturgeon were 13 years or older. The oldest shovelnose sturgeon reported by Helms (1974b) in the Mississippi River, Iowa, was a 12-year-old measuring 716 mm (28.2 in.) in fork length. However, Christenson (1975) seemed to question the rapid growth rates and young ages reported by Helms. Christenson observed a very slow growth rate for tagged and recaptured shovelnose sturgeon in the Red Cedar/Chippewa River system in Wisconsin. Christenson felt his tagging method should have had a negligible effect on sturgeon growth rates. He concluded it was unlikely that shovelnose sturgeon in the Red Cedar/Chippewa River system were only 12 years old at approximately 710 mm (27.9 in.) in fork length. Schmulbach (1974) also observed a very slow growth rate for tagged and recaptured shovelnose sturgeon in the Missouri River near Vermillion, South Dakota.

Male shovelnose sturgeon sampled from the middle Missouri River averaged 20.6 years of age and ranged from 9 to 29 years. About one-third of the sturgeon 25 years or older were males. The youngest ripe male in the sample was a 10-year-old. Female sturgeon averaged 22.6 years and ranged from 14 to 33 years. About two-thirds of the sturgeon 25 years old or older were females. The youngest female with egg development in the sample was a 16-year-old. The data indicate that female sturgeon mature at an older age and live longer than males.

The aging technique used for shovelnose sturgeon was validated by two forms of evidence. First, there was a highly significant correlation ($r = 0.84$, $P < .01$) between body length and anterior pectoral fin ray section radius. Second, sturgeon of increasing lengths were generally assigned ages of increasing magnitude (Table 21).

Length/Weight Relationship

Shovelnose sturgeon sampled in 1978 and 1979 ranged from 533 to 945 mm (21.0 to 37.2 in.) in fork length and averaged 758 mm (29.8 in.). Mean weight of the sturgeon in the sample was 2191 g (4.83 lb). The length/weight relationship for sturgeon in the sample is described by the equation: $\log W = 3.22 \log L - 5.95$ ($r = 0.93$), where W = weight and L = fork length.

Forty-one shovelnose sturgeon sexed as males averaged 739 mm (29.1 in.) in fork length and 1969 g (4.34 lb). Fifty females averaged 782 mm (30.8 in.) in fork length and 2472 g (5.45 lb). The average length and weight of shovelnose sturgeon sampled from the middle Missouri River in 1978 and 1979 equal or exceed the maximum lengths and weights reported for shovelnose sturgeon in samples from the Missouri River in South Dakota (Zweiacker 1967), Mississippi River in Iowa (Helms 1974a), and the Red Cedar/Chippewa River system in Wisconsin (Christenson 1975). Mean lengths and weights of shovelnose sturgeon in the Tongue River, Montana (Elser et al. 1977),

Table 21. Age-frequency of shovelnose sturgeon sampled from the middle Missouri River in 1978 and 1979 with mean fork length, weight and condition factor (K_{TL}) of each age class.

Age	No. of Fish	Mean Fork Length (mm)	Mean Weight (g)	Mean KTL
8	2	579	826	0.43
9	1	566	703	0.38
10	2	655	1179	0.42
11	0	-	-	-
12	0	-	-	-
13	1	686	1505	0.47
14	3	663	1442	0.49
15	7	683	1578	0.50
16	2	711	1828	0.51
17	5	701	1683	0.49
18	9	749	1647	0.40
19	12	749	1978	0.47
20	13	729	1896	0.49
21	7	762	2109	0.48
22	11	754	2109	0.49
23	7	759	2127	0.49
24	9	785	2667	0.55
25	8	813	2690	0.50
26	6	772	2495	0.54
27	2	790	2717	0.55
28	4	820	2839	0.52
29	3	813	2930	0.55
30	1	914	3946	0.52
31	3	874	3266	0.49
32	3	902	3878	0.53
33	1	853	3774	0.61

Powder River, Montana (Rehwinkel et al. 1976), were similar to the middle Missouri River.

Condition Factors

Mean condition factors were higher for shovelnose sturgeon over 21 years (the mean age) than for sturgeon younger than 21 (Table 21). Mean condition factors were 0.46 for fish less than 21 years and 0.52 for fish more than 21.

The average condition factor for all shovelnose sturgeon sampled from the middle Missouri River was 0.503. Condition factors averaged 0.487 for males and 0.517 for females. Condition factors reported by Carlander (1969) for shovelnose sturgeon in reservoirs on the Missouri River in South Dakota were much lower, ranging from 0.22 to 0.27. Elser et al. (1977) reported data which indicated mean condition factors of 0.481 for males and 0.611 for females in the lower Tongue River, Montana, in 1975. Since the shovelnose sturgeon population in the lower Tongue River was comprised almost entirely of mature spawning fish, the high condition factor of female sturgeon is probably related to the presence of a large number of gravid fish. The middle Missouri River sample included a significant number of immature and nonspawning females, which more nearly reflects an average condition factor for female shovelnose sturgeon.

Channel Catfish

Assigned Ages and Observed Growth

In 1978, 234 channel catfish sampled on the middle Missouri River were assigned ages ranging from 1 to 18 years (Table 22). Age determinations were made by examining cross-sections of the pectoral spine (Figure 26). Since the sampling gear was selective for larger fish, only 4 percent of the channel catfish in the sample were 2 years or younger. Three and four-year-old channel catfish made up 66 percent of the sample. About 30 percent of the channel catfish were age five or older. Ragland and Robinson (1972) reported that 3 and 4-year-old channel catfish made up 61 percent of a sample of channel catfish from the lower Missouri River in Missouri. They concluded the most likely cause for the dominance of catfish of intermediate size and age was gear selectivity.

In general, the middle Missouri River channel catfish population appears to be older than populations in the lower Missouri River, Missouri (Ragland and Robinson 1972), Lake-of-the-Ozarks, Missouri (Marzolf 1955), Grand Lake, Oklahoma (Sneed 1951), and the Salt River, Missouri (Purkett 1957). The channel catfish population in the St. Lawrence River in Quebec (Carlander 1969) appears to be older than the middle Missouri population in Montana. Carlander (1969) reported that channel catfish reach sexual maturity at 303 to 381 mm (11.9 to 15.0 in.) and 4 to 5 years of age in the Mississippi River in Iowa and Missouri. If this is true for the middle Missouri River population in Montana, probably half or less of the sample of 234 channel catfish collected in 1978 were sexually mature.

Growth of channel catfish in the middle Missouri River is superior to growth in the Tongue River, Montana (Elser et al. 1977), Des Moines River, Iowa (Carlander 1969), and St. Lawrence River, Quebec (Carlander 1969), and similar to average growth in the Mississippi and Missouri

Table 22. Age-frequency of channel catfish sampled from the middle Missouri River in 1978 with mean length, weight and condition factor (K_{TL}) of each age class.

Age	No. of Fish	% of Sample	Mean Length (mm)	Mean Weight (g)	Mean KTL
1	2	0.9	186	61	0.93
2	7	3.0	256	148	0.88
3	69	29.2	304	227	0.80
4	87	36.9	373	417	0.79
5	9	3.8	428	641	0.81
6	15	6.4	471	869	0.82
7	9	3.8	496	1067	0.87
8	7	3.0	542	1424	0.89
9	4	1.7	527	1325	0.89
10	3	1.3	587	2008	0.95
11	3	1.3	582	1837	0.93
12	3	1.3	648	3007	1.11
13	2	0.9	701	4105	1.19
14	7	3.0	669	3334	1.11
15	5	2.1	690	3656	1.11
16	0	0	-	-	-
17	2	0.9	718	4604	1.24
18	2	0.9	658	2767	0.97

rivers (as calculated by Carlander 1969) through age six (Table 23). For channel catfish 7 years and older, growth in the middle Missouri River is slower than average. However, since channel catfish in the middle Missouri live longer than average, the size structure of the population is nearly identical to that in other portions of the Mississippi and Missouri rivers.

The aging technique used for channel catfish was validated by three forms of evidence. First, there was an increase in ages assigned to catfish of increasing length (Table 22). Second, there was a highly significant correlation between body length and pectoral spine section radius ($r = 0.87$, $P < .01$). Third, calculated lengths at annuli 1 through 10 showed reasonable agreement with observed mean lengths of assigned age classes.

Length/Weight Relationship

Channel catfish sampled in 1978 ranged from 175 to 787 mm (6.9 to 31.0 in.) in total length and averaged 371 mm (14.6 in.). Weights ranged from 45 to 5488 g (0.10 to 12.10 lb) and averaged 771 g (1.70 lb). The length/weight relationship for channel catfish in the sample is described by the equation: $\log W = 3.187 \log L - 5.563$ ($r = 0.99$), where W = weight and L = total length.

Condition Factors

Condition factors of channel catfish showed a tendency to increase with age (Table 22). Mean condition factors of the various age groups ranged

Table 23. Observed growth of channel catfish sampled from the middle Missouri River in 1978 compared to observed growth in other waters. The number of fish sampled is shown in parentheses.

Stream	Mean Length (mm) of Channel Catfish in Age Group																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Middle Missouri River (present study)	186 (2)	256 (7)	304 (69)	373 (87)	428 (9)	471 (15)	496 (9)	542 (7)	527 (4)	587 (3)	582 (3)	648 (3)	701 (2)	669 (7)	690 (5)	- (0)	718 (2)	658 (2)
Tongue River, Montana (Elser et al. 1977)	127 (2)	206 (28)	229 (9)	272 (21)	318 (17)	335 (19)	373 (6)	389 (7)	414 (22)	450 (13)	485 (16)	531 (29)	531 (24)	577 (14)	574 (3)			
Missouri R. Missouri (Ragland & Robinson 1972)	137 (6)	239 (37)	312 (59)	381 (130)	447 (193)	470 (89)	518 (15)	584 (8)	683 (2)									
Des Moines R., Iowa (Carlander 1969)	86 (4)	147 (161)	213 (332)	249 (297)	300 (346)	333 (117)	363 (64)	376 (17)	363 (7)	371 (4)	427 (2)	437 (1)	592 (1)					
St. Lawrence R., Que. (Carlander 1969)								361 (3)	386 (1)	401 (4)	406 (2)	432 (3)	447 (2)	442 (2)	447 (1)	486 (2)	495 (1)	486 (3)
Miss. & Mo. Rivers combined average (Carlander 1969)	-	241 (357)	315 (1034)	368 (1153)	437 (203)	472 (200)	533 (131)	561 (39)	607 (12)	711 (1)	665 (2)	724 (2)						

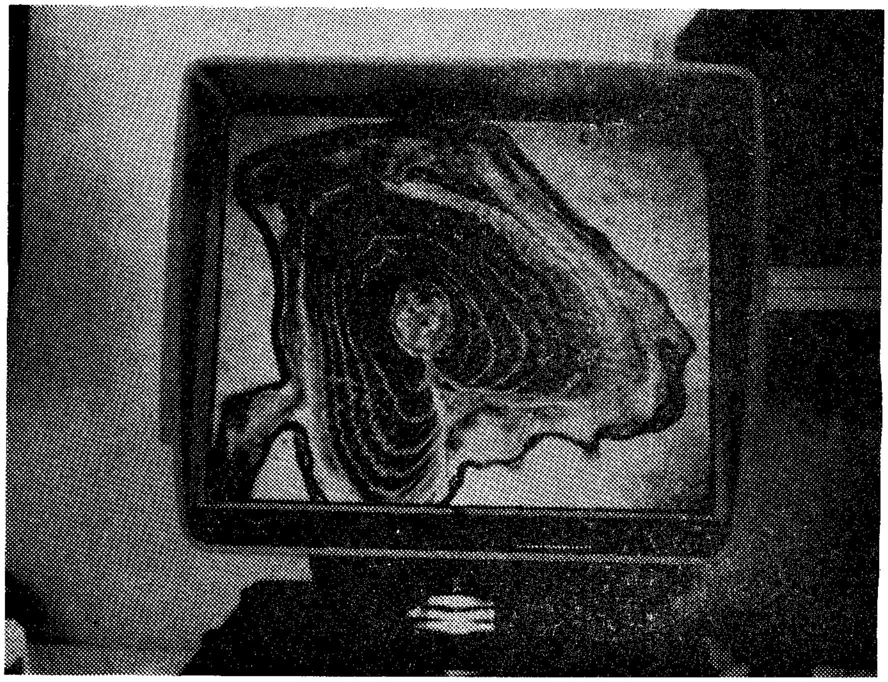


Figure 26. Cross-sections of the pectoral spines of channel catfish were studied for age and growth determination.

from 0.79 to 1.24. Carlander (1969) reported condition factors of channel catfish populations in five midwestern states ranged from 0.50 to 1.22.

Calculated Growth

Calculated lengths of channel catfish at annuli 1 through 10 are presented in Table 24. The calculations were based on 212 channel catfish from the 1978 sample. The Monastyrsky logarithmic equation best fit the data ($r = 0.87$), indicating curvilinear growth. Growth was greatest during the first three years of life, then continued more slowly, but steadily, through the tenth year. Lee's Phenomenon was apparent in the data for most age classes.

Calculated growth of channel catfish in the middle Missouri River is generally equivalent or superior to growth in other northern waters (Table 25). Channel catfish growth in the middle Missouri River also compares favorably with growth in lakes and rivers in southern states, particularly during the first few years of life.

Table 24. Calculated length at the end of each year of life and average growth of channel catfish sampled from the middle Missouri River in 1978 (Monastyrsky logarithmic method).

		Calculated Total Length (mm) at End of Year									
Age Group	No. Fish	1	2	3	4	5	6	7	8	9	10
1	2	103									
2	7	95	198								
3	69	98	207	285							
4	87	99	209	300	332						
5	9	98	192	271	334	382					
6	15	90	168	246	321	384	411				
7	9	89	169	259	323	378	426	470			
8	7	91	174	266	332	387	426	474	513		
9	4	86	179	262	319	367	406	442	476	508	
10	3	80	155	231	298	345	393	437	478	516	521
Grand Average Calculated Length		97	201	285	329	379	416	462	495	511	521
Grand Average Length Increment		97	104	84	44	50	37	46	33	16	10
No. Fish		212	210	203	131	46	37	23	14	7	3

Sauger

Assigned Ages and Observed Growth

In 1978 and 1979, 802 sauger sampled on the middle Missouri River were assigned ages ranging from 0 to 8 years (Table 26). Ages 0, 1 and 2 made up 23 percent of the sample. The small percentage of sauger in this age range was due to sampling bias. The boom suspended electrofishing boat was much less efficient for sampling smaller, younger sauger than larger, older sauger. Ages 3, 4, and 5 made up 61 percent of the sample. This percentage would have been even higher if the 1979 sample had contained fish from 305 to 405 mm (12.0 to 15.9 in.) in length. Sauger in this size range were not collected in 1979 because an adequate sample was collected in 1978. Ages 6, 7, and 8 made up 16 percent of the sample.

Completion of annuli for sauger in 1978 ranged from June 7 to July 22 and averaged June 29. Time of completion of annuli formation in 1979 ranged from May 19 to July 10 and averaged June 9. Riggs (1978) reported 100 percent completion of annuli formation for sauger in the Tongue River Reservoir by July 11 in 1975 and July 5 in 1976.

Table 25. Calculated growth of channel catfish sampled from the middle Missouri River in 1978 compared to calculated growth in other waters.

Water	No. of Fish	Average Calculated Total Length (mm) at End of Year									
		1	2	3	4	5	6	7	8	9	10
Middle Missouri River (present study)	212	97	201	285	329	379	416	462	495	511	521
Missouri River, Missouri (Ragland & Robinson 1972)	534	53	140	239	330	411	452	508	589	676	-
Des Moines River, Iowa (Carlander 1969)	400	46	124	196	257	312	381	442	490	546	617
Mississippi River, Iowa (Carlander 1969)	91	66	150	211	254	274	315	-	-	-	-
Watts Bar L., Tenn. (Carlander 1969)	55	163	239	290	333	366	404	427	462	488	523
Heyburn L., Ok. (Carlander 1969)	206	86	165	224	305	394	472	561	-	-	-
Salt R., Mo. (lower) (Purkett (1957)	124	66	135	206	259	297	340	399	-	-	-
Moultree L., S. C. (Carlander 1969)	207	86	185	284	368	442	531	602	665	726	773

Table 26. Age-frequency of sauger sampled from the middle Missouri River in 1978 and 1979 with mean length, weight and condition factor (K_{TL}) of each age class.

Age	No. of Fish	% of Sample	Mean Length (mm)	Mean Weight (g)	Mean KTL
0	48	6.0	127	-	.68
1	40	5.0	207	86	.70
2	95	11.9	276	153	.71
3	109	13.7	310	224	.74
4	154	19.3	353	339	.75
5	224	28.1	392	476	.78
6	94	11.8	430	655	.80
7	26	3.3	480	921	.81
8	8	1.0	498	1011	.82

Table 27. Observed growth of sauger sampled from the middle Missouri River in 1978 and 1979 compared to observed growth in other Montana streams. The number of fish sampled is shown in parentheses.

	Mean Length (mm) of Sauger in Age Group								
Stream	0	1	2	3	4	5	6	7	8
Middle Missouri River (present study)	127 (48)	207 (40)	276 (95)	310 (109)	353 (154)	392 (224)	430 (94)	480 (26)	498 (8)
Lower Yellowstone R. (Haddix and Estes 1976)	- (0)	211 (44)	257 (82)	310 (67)	356 (85)	394 (78)	485 (50)	574 (7)	- (0)
Tongue River (Elser et al. 1977)	- (0)	- (0)	- (0)	289 (26)	332 (89)	374 (62)	418 (50)	444 (31)	478 (12)
Powder River (Rehwinkel et al. 1976)	- (0)	- (0)	306 (4)	318 (20)	357 (45)	415 (22)	421 (15)	425 (5)	478 (2)

Table 28. Mean monthly condition factors (K_{TL}) of sauger sampled from the middle Missouri River in 1978 and 1979.

	April	May	June	July	August	September	October
Mean K_{TL}	0.83	0.80	0.71	0.73	0.76	0.81	0.74
No. of Fish	8	49	88	127	319	135	72

Growth of sauger in the middle Missouri River was similar to growth in the lower Yellowstone, Tongue, and Powder rivers through age five. Beyond age five, sauger from the lower Yellowstone River were larger in average size than on the middle Missouri, while sauger from the Tongue and Powder rivers were smaller.

The aging technique used for sauger was validated by three forms of evidence. First, there was a highly significant correlation between body length and scale radius ($r = 0.90$, $P < .01$). Second, sauger of increasing lengths were assigned ages of increasing magnitude (Table 26). Third, observed lengths of assigned age classes showed reasonable agreement with calculated lengths at previous annuli.

Length/Weight Relationship

Sauger sampled in 1978 and 1979 ranged from 39 to 579 mm (1.5 to 22.8 in.) in total length and averaged 350 mm (13.8 in.). Weights ranged from 20 to 1542 g (0.04 to 3.40 lb) and averaged 325 g (0.72 lb). The length/weight relationship for sauger in the sample is described by the equation: $\log W = 3.157 \log L - 5.524$ ($r = 0.99$), where W = weight and L = total length.

Condition Factors

Condition factors of sauger increased consistently with age (Table 26). The condition factors ranged from 0.68 for young-of-the-year to 0.82 for 8-year-olds. Graham et al. (1979) reported condition factors of sauger in the lower Yellowstone River, Montana, ranging from 0.57 to 0.91.

Mean monthly condition factors of sauger were high in April, decreased in May and June, and increased slowly from July through September (Table 28). The condition factor decreased again in October. The pattern of seasonal change in condition factors is probably related to spawning, feeding, and recruitment characteristics of the population.

Calculated Growth

Calculated lengths of sauger at annuli 1 through 8 are presented in Table 29. The calculations were based on 735 sauger from the combined 1978-79 sample. The Monastyrsky logarithmic equation best fit the data ($r = 0.90$), indicating curvilinear growth (Table 30). Calculated growth of sauger in the middle Missouri River is generally superior to growth in other northern waters at the end of the first year of life, similar to other northern waters at the end of the second and third years, and inferior after the third year (Table 31).

Blue Sucker

Assigned Ages and Observed Growth

In 1978 and 1979, 214 blue suckers sampled on the middle Missouri River were assigned ages ranging from 6 to 17 years (Table 32). Over 70 percent of the fish in the sample were 11 years of age or older. The old ages of blue suckers in the sample could be related to sampling bias or differential distribution of the younger blue suckers. The sample was probably comprised almost entirely of mature fish.

Table 29. Calculated length at the end of each year of life and average growth of sauger sampled from the middle Missouri River in 1978 and 1979 (Monastyrsky logarithmic method).

		Calculated Total Length (mm) at End of Year							
Age Group	No. Fish	1	2	3	4	5	6	7	8
1	40	154							
2	95	155	250						
3	109	147	227	282					
4	154	151	240	298	344				
5	224	148	236	296	329	377			
6	94	152	234	289	336	379	413		
7	26	153	235	295	347	393	432	463	
8	8	148	228	280	331	381	422	456	485
Grand Average Calculated Length		151	237	293	336	379	417	462	485
Grand Average Length Increment		151	86	56	43	43	38	45	23
No. Fish		735	708	615	506	351	128	34	8

Table 30. Comparison of grand average calculated lengths of sauger at the end of each year of life using a logarithmic method (Monastyrsky) and three linear methods. Calculations are based on 735 sauger sampled from the middle Missouri River in 1978 and 1979.

	Average Calculated Total Length (mm) at End of Year							
Method	1	2	3	4	5	6	7	8
Monastyrsky	151	237	293	336	379	417	462	485
Dahl Lea	127	210	263	301	341	376	416	439
Rosa Lee	157	240	292	331	371	406	446	469
Rosa Lee (corrected)	157	240	294	337	379	417	462	485

Table 31. Calculated growth of sauger sampled from the middle Missouri River in 1978 and 1979 compared to calculated growth in other northern waters.

Water	No. of Fish	Average Calculated Total Length (mm) at End of Year							
		1	2	3	4	5	6	7	8
Middle Missouri River (present study)	735	151	237	293	336	379	417	462	485
Lower Yellowstone River (Graham et al. 1979)	859	157	244	305	365	424	476	534	
Marias R., Montana (Peters 1964)	16	112	203	282	335	384	465		
Milk R., Montana (Peters 1964)	5	130	246	323	366				
Fort Peck Res., Mont. (Peters 1964)	124	130	224	297	363	429	493	521	
Garrison Res., N. Dak. (Carufel 1963)	318	125	221	310	386	461	587		
L. Winnebago, Wisc. (Priegel 1969)	1741	130	246	310	338	358	378	391	401
Upper Mississippi R. Backwaters (Christenson and Smith 1965)	42	124	229	302	345				

Table 32. Age-frequency of blue suckers sampled from the middle Missouri River in 1978 and 1979 with mean length, weight and condition factor (K_{TL}) of each age class.

Age	No. of Fish	% of Sample	Mean Length (mm)	Mean Weight (g)	Mean KTL
6	1	0.5	556	1338	0.78
7	2	0.9	609	2043	0.91
8	7	3.3	625	2051	0.88
9	30	14.0	670	2590	0.85
10	21	9.8	658	2551	0.90
11	52	24.3	704	2985	0.88
12	40	18.7	734	3578	0.90
13	34	15.9	747	3774	0.92
14	17	7.9	774	4277	0.89
15	6	2.8	799	4763	0.93
16	3	1.4	841	5053	0.89
17	1	0.5	793	5035	0.89

Very few studies have been made of the age and growth of blue suckers, probably because of the scarcity of the species. Carlander (1969) summarized age and growth observations for a few blue suckers collected from the Missouri River in South Dakota and two lakes in Oklahoma. Observed growth of blue suckers in the middle Missouri River is similar to these waters for comparable age groups.

Length/Frequency Distribution

The length/frequency distribution of blue suckers sampled in 1978 and 1979 is given in Table 33. The fish ranged from 556 to 879 mm (21.9 to 34.6 in.) in total length, and averaged 714 mm (28.1 in.). Christenson (1974) collected 181 blue suckers in the Red Cedar/Chippewa River system in Wisconsin. He reported a size range of 470 to 755 mm (18.5 to 29.7 in.) total length with a mean size of 625 mm (24.6 in.). Carlander (1969) reported blue suckers collected from three locations on the Missouri River in South Dakota ranged from 432 to 686 mm (17.0 to 27.0 in.) in total length.

Length/Weight Relationship

Weights of blue suckers sampled from the middle Missouri River ranged from 1338 to 6577 g (2.95 to 14.50 lb) and averaged 3305 g (7.29 lb). Christenson (1974) reported weights for blue suckers which ranged from 1270 to 3992 g (2.80 to 8.80 lb) and averaged 2177 g (4.80 lb) in the Red Cedar/Chippewa River system in Wisconsin. Weights of blue suckers collected from Oahe Reservoir on the Missouri River in South Dakota ranged from 186 to 2504 g (0.41 to 5.52 lb) (Carlander 1969).

The length/weight relationship for blue suckers sampled in the middle Missouri River is described by the equation: $\log W = 2.792 \log L - 4.466$ ($r = 0.89$), where W = weight and L = total length. A length/weight relationship reported for blue suckers in Alabama by Carlander (1969) was described by the equation: $\log W = 3.19 \log L - 5.57$. This equation predicts weights similar to those predicted by the middle Missouri River equation.

Condition Factors

The mean condition factor for the entire sample of blue suckers from the middle Missouri River was 0.88. Condition factors reported by Carlander (1969) for blue suckers collected from three locations on the Missouri River in South Dakota ranged from 0.67 to 0.76.

Mean monthly condition factors of blue suckers sampled in the middle Missouri River are given in Table 34. Mean condition factor was lowest in June, probably the result of fish having completed spawning.

Calculated Growth

An attempt was made to calculate lengths of blue suckers at previous annuli. However, due to the lack of smaller and younger fish, results were very poor and are not included in this report.

Table 33. Length-frequency distribution of blue suckers sampled on the middle Missouri River in 1978 and 1979.

Length Interval (mm)	No. of Fish	Percent of Sample
540-559	1	0.5
560-579	0	-
580-599	0	-
600-619	7	3.4
620-639	8	3.9
640-659	15	7.3
660-679	25	12.2
680-699	32	15.6
700-719	21	10.2
720-739	26	12.7
740-759	16	7.8
750-779	27	13.2
780-799	8	3.9
800-819	9	4.4
820-839	8	3.9
840-859	1	0.5
860-879	1	0.5
Total	205	

Table 34. Mean monthly condition factors (K_{TL}) of blue suckers sampled from the middle Missouri River in 1978 and 1979.

	May	June	July	August	September	October
Mean K_{TL}	0.87	0.81	0.87	0.91	0.98	0.95
No. of Fish	25	33	71	68	1	6

Assigned Ages and Observed Growth

In 1978 and 1979, 180 smallmouth buffalo sampled on the middle Missouri River were assigned ages ranging from 4 to 16 years (Table 35). About 10 percent were 4 to 8 years old, 73 percent were 9 to 12, and 17 percent were 13 to 16. Smallmouth buffalo in the Missouri River in South Dakota first reach sexual maturity at age 4. Brown (1971) indicates smallmouth buffalo in Montana usually reach maturity at age three. This indicates that the sample of smallmouth buffalo from the middle Missouri River was probably comprised entirely of mature fish, spawners from Fort Peck Reservoir. Immature smallmouth buffalo rear in the reservoir.

Observed growth of smallmouth buffalo in the middle Missouri is about average when compared to observed growth reported by Carlander (1969) for other waters in the United States.

The aging technique used for smallmouth buffalo was validated by three forms of evidence. First, there was a highly significant correlation between body length and scale radius ($r = 0.84$, $P < .01$). Second, smallmouth buffalo of increasing lengths were assigned ages of increasing magnitude. Third, observed lengths of assigned age classes showed reasonable agreement with calculated lengths at previous annuli.

Length/Weight Relationship

Smallmouth buffalo sampled in 1978 and 1979 ranged from 404 to 800 mm (15.9 to 31.5 in.) in total length and averaged 576 mm (22.7 in.). Weights ranged from 975 to 7498 g (2.15 to 16.53 lb) and averaged 3120 g (6.88 lb). The length/weight relationship for smallmouth buffalo in the sample is described by the equation: $\log W = 2.96 \log L - 4.698$ ($r = 0.92$), where W = weight and L = total length.

Table 35. Age-frequency of smallmouth buffalo sampled from the middle Missouri River in 1978 and 1979 with mean length, weight and condition factor (K_{TL}) of each age class.

Age	No. of Fish	% of Sample	Mean Length (mm)	Mean Weight (g)	Mean KTL
4	1	0.6	404	975	1.48
5	0	0	-	-	-
6	0	0	-	-	-
7	3	1.7	478	1588	1.48
8	14	7.8	513	2030	1.56
9	39	21.7	549	2564	1.53
10	42	23.3	573	2882	1.58
11	32	17.8	597	3424	1.59
12	18	10.0	623	3724	1.62
13	22	12.2	635	4201	1.60
14	7	3.9	685	5270	1.72
15	1	0.6	696	5557	1.71
16	1	0.6	704	5670	1.73

Condition Factors

In general, condition factors of smallmouth buffalo increased with age (Table 35). Mean condition factors for the various age groups ranged from 1.48 to 1.73. Condition factors were high in April, decreased in May and June, and increased from July through October (Table 36). The pattern of seasonal change in condition factors is probably related to spawning, which occurs mainly from late May through late June.

Table 36. Mean monthly condition factors (K_{TL}) of smallmouth buffalo sampled from the middle Missouri River in 1978 and 1979.

	April	May	June	July	August	September	October
Mean K_{TL}	1.74	1.53	1.48	1.53	1.64	1.70	1.70

Calculated Growth

Erosion of the edges of the scales and annuli distortions made it difficult to calculate growth increments of smallmouth buffalo at previous annuli. Only 15 scale samples were suitable for age and growth determination by this method. The scales were from fish 10 years of age or younger.

Calculated lengths at previous annuli for this sample of smallmouth buffalo are presented in Table 37. The Monastyrsky logarithmic equation best fit the data and most accurately described the growth increments.

Calculated growth of smallmouth buffalo in the middle Missouri River is similar to other waters (Table 38). Carlander (1969) found no regional trends in growth rates of smallmouth buffalo when he compared growth in various parts of the United States.

Bigmouth Buffalo

Assigned Ages and Observed Growth

In 1978 and 1979, 72 bigmouth buffalo sampled on the middle Missouri River were assigned ages ranging from 5 to 15 years (Table 39). Only 12.5 percent of the fish were younger than 10, and 87.5 percent were 10 or older. Carlander (1969) reported bigmouth buffalo in the Missouri River in South Dakota mature at ages 3 to 4. Brown (1971) indicates bigmouth buffalo in Montana usually reach maturity at age three. This indicates that the sample of bigmouth buffalo from the middle Missouri River was probably comprised entirely of mature fish, spawners from Fort Peck Reservoir. Immature bigmouth buffalo rear in the reservoir.

Bigmouth buffalo in the middle Missouri River appeared to form their annulus mark between late May and mid-June. This is similar to the time of annulus formation reported for bigmouth buffalo in the Missouri River in South Dakota (Carlander 1969).

Table 37. Calculated length at the end of each year of life and average growth of smallmouth buffalo sampled from the middle Missouri River in 1978 and 1979 (Monastyrsky logarithmic method).

		Calculated Total Length (mm) at End of Year									
Age Group	No. Fish	1	2	3	4	5	6	7	8	9	10
1	0	-									
2	0	-	-								
3	0	-	-	-							
4	1	136	198	291	349						
5	0	-	-	-	-	-					
6	0	-	-	-	-	-	-				
7	3	134	221	295	354	394	426	458			
8	5	128	204	262	326	379	416	447	475		
9	1	129	200	254	304	354	390	426	453	488	
10	3	141	222	287	342	389	424	464	498	526	550
Grand Average Calculated Length		133	211	277	336	383	418	452	480	516	550
Grand Average Length Increment		133	78	66	59	47	35	34	28	36	34
No. Fish		13	13	13	13	12	12	12	9	4	3

Table 38. Calculated growth of smallmouth buffalo sampled from the middle Missouri River in 1978 and 1979 compared to calculated growth in other waters.

Water	No. of Fish	Average Calculated Total Length (mm) at End of Year									
		1	2	3	4	5	6	7	8	9	10
Middle Missouri River (present study)	13	133	211	277	336	383	418	452	480	516	550
Salt River, Missouri (Purkett 1957)	71	130	244	325	381	429	493	521	554		
St. Francis R., Missouri (Carlander 1969)	50	127	201	254	295	330	363	396	460	490	526
Rock Creek, Oklahoma (Carlander 1969)	14	104	163	203	244	290	330	336	419		

Table 39. Age-frequency of bigmouth buffalo sampled from the middle Missouri River in 1978 and 1979 with mean length, weight and condition factor (K_{TL}) of each age class.

Age	No. of Fish	% of Sample	Mean Length (mm)	Mean Weight (g)	Mean KTL
5	1	1.4	432	1,202	1.49
6	0	0	-	-	-
7	1	1.4	640	3,856	1.47
8	0	0	-	-	-
9	7	9.7	707	5,811	1.64
10	12	16.7	714	5,816	1.60
11	17	23.6	714	5,944	1.63
12	14	19.4	801	9,593	1.87
13	14	19.4	813	9,536	1.77
14	5	6.9	854	10,614	1.70
15	1	1.4	790	7,824	1.59

Table 40. Calculated length at the end of each year of life and average growth of bigmouth buffalo sampled from the middle Missouri River in 1978 and 1979 (Monastyrsky logarithmic method).

		Calculated Total Length (mm) at End of Year									
Age Group	No. Fish	1	2	3	4	5	6	7	8	9	10
1	0	-									
2	0	-	-								
3	0	-	-	-							
4	0	-	-	-	-						
5	1	111	185	245	310	383					
6	0	-	-	-	-	-	-				
7	1	140	275	397	473	548	578	607			
8	0	-	-	-	-	-	-	-	-		
9	5	144	241	363	440	513	568	612	652	687	
10	6	133	229	332	415	465	526	578	622	662	691
Grand Average Calculated Length		136	234	342	421	484	548	595	636	673	691
Grand Average Length Increment		136	98	108	79	63	64	47	41	37	18
No. Fish		13	13	13	13	13	12	12	11	11	6

Observed growth of bigmouth buffalo in the middle Missouri River is about average when compared to observed growth reported by Carlander (1969) for other waters in the United States.

The aging technique used for bigmouth buffalo was validated by three forms of evidence. First, there was an increase in ages assigned to bigmouth buffalo of increasing length (Table 39). Second, there was a highly significant correlation between body length and scale radius ($r = 0.88$, $P < .01$). Third, calculated lengths at previous annuli showed reasonable agreement with observed mean lengths of assigned age classes.

Length/Weight Relationship

Bigmouth buffalo sampled in 1978 and 1979 ranged from 432 to 914 mm (17.0 to 36.0 in.) in total length and averaged 756 mm (29.8 in.). Weights ranged from 1202 to 14,061 g (2.65 to 31.00 lb) and averaged 7566 g (16.68 lb). The length/weight relationship for bigmouth buffalo in the sample is described by the equation: $\log W = 3.391 \log L - 5.898$ ($r = 0.96$), where W = weight and L = total length.

Condition Factors

In general, condition factors of bigmouth buffalo increased with age (Table 39). Mean condition factors for the various age groups ranged from 1.47 to 1.87. Carlander reported condition factors of bigmouth buffalo in reservoirs on the Missouri River in South Dakota ranged from 1.39 to 1.88.

Calculated Growth

Growth of bigmouth buffalo in the middle Missouri River is best described by the Monastyrsky logarithmic equation. Calculated lengths at annuli 1 through 10 are presented in Table 40. Growth was very rapid during the first five years of life. Growth continued more slowly through years 6 to 10.

Calculated growth of bigmouth buffalo in the middle Missouri River is similar to other waters (Table 41). Carlander (1969) indicated growth of bigmouth buffalo in Saskatchewan lakes was slower than in southern waters, but other regional differences in the United States and Canada were not distinguishable.

Freshwater Drum

Assigned Ages and Observed Growth

In 1979, 86 freshwater drum sampled on the middle Missouri River were assigned ages ranging from 2 to 10 years (Table 42). Fish of 4, 5, and 7 years comprised 58 percent of the sample. Six-year-old fish (the 1973 year class) were poorly represented.

The aging technique used for freshwater drum was validated by three forms of evidence. First, there was a highly significant correlation between body length and scale radius ($r = 0.92$, $P < .01$). Second, freshwater drum of increasing lengths were assigned ages of increasing magnitude (Table 42). Third, observed lengths of assigned age classes showed reasonable agreement with calculated lengths at previous annuli.

Table 41. Calculated growth of bigmouth buffalo sampled from the middle Missouri River in 1978 and 1979 compared to calculated growth in other waters.

Water	No. of Fish	Average Calculated Total Length (mm) at End of Year 1	2	3	4	5	6	7	8	9	10
Middle Missouri R. (present study)	13	136	234	342	421	484	548	595	636	673	691
Missouri R., Iowa (Carlander 1969)	5	135	244	330	368	388					
Roosevelt L., Ariz. (Carlander 1969)	490	208	361	455	503	538	569	597	582		
Coralville Res., Iowa (Carlander 1969)	236	175	328	388	432	467	513	584	678	688	703

Table 42. Age-frequency of freshwater drum sampled from the middle Missouri River in 1979 with mean length, weight and condition factor (K_{TL}) of each age class.

Age	No. of Fish	% of Sample	Mean Length (mm)	Mean Weight (g)	Mean KTL
1	0	0	-	-	-
2	7	8.1	276	285	1.34
3	10	11.6	298	342	1.29
4	16	18.6	329	476	1.32
5	17	19.8	352	600	1.36
6	8	9.3	387	816	1.39
7	17	19.8	426	1203	1.49
8	8	9.3	451	1406	1.52
9	2	2.3	499	1996	1.59
10	1	1.2	526	1973	1.38

Observed growth of freshwater drum in the middle Missouri River is shown in Table 42. Growth increased fairly consistently with age and did not appear to slow down in older age groups.

Length/Weight Relationship

Freshwater drum sampled in 1979 ranged from 267 to 528 mm (10.5 to 20.8 in.) in total length and averaged 362 mm (14.3 in.). Weights ranged from 227 to 2313 g (0.50 to 5.10 lb) and averaged 765 g (1.69 lb). The length/weight relationship for freshwater drum in the sample is described by the equation: $\log W = 3.295 \log L - 5.612$ ($r = 0.99$), where W = weight and L = total length.

Condition Factors

Condition factors of freshwater drum in the middle Missouri River generally increased with age (Table 42). Mean condition factors for the various age groups ranged from 1.29 to 1.59. All of the freshwater drum in the sample were collected in July and August.

Calculated Growth

Calculated lengths of freshwater drum at annuli 1 through 10 using the Monastyrsky logarithmic equation are given in Table 43. The calculations were based on 84 freshwater drum from the 1979 sample. The Monastyrsky equation fit the data better than linear equations, indicating growth of freshwater drum was curvilinear.

Calculated growth of freshwater drum in the middle Missouri River is compared with calculated growth in the Salt River, Missouri (Purkett 1957) in Table 44. The calculated growth for the middle Missouri River is slightly inferior to growth in the Salt River. Apparently, very few studies have been made of the age and growth of freshwater drum. The Salt River study by Purkett was the only one located in a brief review of the literature.

Other Species

Age determinations were made for 15 walleye, 4 brown trout, 2 rainbow trout, 1 mountain whitefish, and 1 northern pike collected on the middle Missouri River in 1978 and 1979 (Table 45). Sample sizes for these species were too small to calculate detailed age and growth statistics.

Forage Fish

Piscivorous game and nongame fish populations depend, in part, on an adequate forage fish base for their food supply. The major fish species in the middle Missouri River which use forage fish for all or part of their diet include sauger, walleye, northern pike, channel catfish, burbot, and goldeye.

Forage fish populations were inventoried from 1976 through 1980 in eleven study sections on the mainstem of the middle Missouri River and in one study area on the lower Marias River. A comprehensive summary of the surveys is given in Appendix Table 56.

The main objective of the sampling was to determine taxonomic composition, longitudinal distribution, and habitat preferences of forage fish populations

Table 43. Calculated length at the end of each year of life and average growth of freshwater drum sampled from the middle Missouri River in 1979 (Monastyrsky logarithmic method).

		Calculated Total Length (mm) at End of Year									
Age Group	No. Fish	1	2	3	4	5	6	7	8	9	10
1	0	-									
2	7	146	226								
3	10	138	216	266							
4	16	121	200	256	301						
5	17	121	196	253	295	330					
6	8	115	187	244	289	328	365				
7	17	124	196	251	297	339	373	405			
8	8	117	197	248	294	332	372	407	435		
9	2	132	200	251	298	349	389	427	452	477	
10	1	129	204	258	318	362	403	433	467	496	513
Grand Average Calculated Length		125	201	253	297	334	373	408	441	483	513
Grand Average Length Increment		125	76	52	44	37	39	35	33	42	30
No. Fish		84	84	77	67	52	35	27	10	3	1

Table 44. Calculated growth of freshwater drum sampled from the middle Missouri River in 1979 compared to calculated growth in the Salt River, Missouri.

		Average Calculated Total Length (mm) at End of Year									
Water	No. of Fish	1	2	3	4	5	6	7	8	9	10
Middle Missouri R. (present study)	84	125	201	253	297	334	373	408	441	483	513
Salt R., Missouri Middle Station (Purkett 1957)	130	130	229	287	335	378	419	454	483	511	
Salt R., Missouri Lower Station (Purkett 1957)	365	119	211	267	315	351	399	419	449		

Table 45. Ages of several miscellaneous fish species sampled from the middle Missouri River in 1978 and 1979.

Species, Year Collected	Length (mm)	Weight (g)	Assigned Age
Walleye, 1978	254	131	1
	318	254	2
	373	431	4
	559	1538	6
	658	3538	7
	711	4627	9
	762	5965	9
Walleye, 1979	257	118	2
	279	168	3
	292	181	2
	302	200	2
	310	236	3
	693	3583	7
	696	3629	8
	734	3924	10
Brown Trout, 1979	279	249	2
	287	249	2
	373	658	3
	381	612	4
Rainbow Trout, 1979	264	181	2
	513	2336	5
Mountain Whitefish, 1979	348	386	4
Northern Pike, 1979	914	5216	7

in the study area. Most of the forage fish sampling sites were located in confined areas of the river, such as backwaters and side channels, where the presence of forage fish was considered likely. Some forage fish were also taken in the main channel, particularly in shoreline and shallow riffle areas. Forage fish samples were collected with beach seines.

For the purposes of this report, a forage fish is broadly defined as any fish used by another fish as a food source. This definition includes nearly all young-of-the-year (YOY) fish. Some species, such as mottled sculpin, stonecats, mountain suckers, and most of the cyprinids, seldom exceed 150 mm (6 in.) in length as adults. These species essentially remain as a food source for their entire lives.

Thirty-one forage fish species representing 10 families were collected in the surveys (Table 46). The most common species were flathead chubs, emerald shiners, western silvery minnows, longnose dace, mountain suckers, stonecats, mottled sculpin, YOY carp, YOY shorthead redhorse, and YOY longnose suckers. Mottled sculpin, longnose dace, mountain suckers, YOY longnose suckers, and YOY shorthead redhorse were most abundant in the upper portion of the Missouri River above the confluence of the Marias River. Flathead chubs, stonecats, and YOY carp were more common below the confluence of the Marias. Western silvery minnows and emerald shiners were equally common above and below the mouth of the Marias.

Stonecats, mottled sculpin, longnose dace, and mountain suckers were found principally in riffle habitat. Flathead chubs and YOY longnose suckers were common in both riffles and pools. Emerald shiners, western silvery minnows, YOY shorthead redhorse, and YOY carp were more abundant in pools than in riffles.

For a more detailed discussion of the longitudinal distribution and habitat preferences of forage fish in the middle Missouri River refer to Gardner and Berg (1981).

FINDINGS - SPORT FISHING VALUES

Paddlefish Creel Census

Background

Paddlefish are native to Montana waters. However, little angler interest in them occurred until 1962. At that time a number of paddlefish were taken by anglers below an irrigation diversion structure on the Yellowstone River near Intake. This fishery stimulated interest in paddlefishing, and in addition to the Yellowstone River fishery, a good fishery now exists in the Missouri River immediately upstream from Fort Peck Reservoir and in the dredge cut pond complex below Fort Peck Dam.

Fishing pressure on paddlefish reportedly has increased considerably in recent years in the Missouri River immediately upstream from Fort Peck Reservoir (Needham 1973). This created the need for information required to evaluate the effect of angler harvest on the paddlefish population. In response to this need, a creel census study was implemented in 1973 by the Fisheries Division, DFWP (Needham 1973). This study also included tagging of paddlefish and collection of size and sex data. This research was continued by the Fisheries Division in 1974 and 1975 (Needham 1975 and

Table 46. Longitudinal distribution of forage fish species sampled in the middle Missouri River during the period from 1976 through 1980.

Fish Species	Morony Dam	Carter Ferry	Fort Benton	Loma Ferry	Coal Banks Landing	Hole-in-the-Wall	Judith Landing	Stafford Ferry	Cow Island	Robinson Bridge	Turkey Joe	Marias River	Teton River
YOY goldeye				*	*	*	*	*	*	*	*		
YOY mt. whitefish		*			*							*	
YOY carp	*	*	*	*	*	*	*	*	*	*	*	*	
Flathead chub	*	*	*	*	*	*	*	*	*	*	*	*	*
Sturgeon chub							*		*	*			*
Sicklefin chub									*	*	*		
Lake chub	*	*	*	*	*	*	*						
Emerald shiner	*	*	*	*	*	*	*	*	*	*	*	*	*
Brassy minnow											*		*
Plains minnow	*	*		*					*	*		*	*
W. silvery minnow	*	*	*	*	*	*	*	*	*	*	*	*	
Fathead minnow	*	*	*	*	*	*	*		*	*		*	
Longnose dace	*	*	*	*	*	*	*	*	*	*	*	*	*
YOY r. carpsucker				*	*	*	*	*	*	*	*		*
YOY sm. buffalo			*	*			*		*		*		
YOY bm. buffalo			*	*			*						
YOY sh. redhorse	*	*	*	*	*	*	*	*	*	*	*	*	*
YOY longnose sucker	*	*	*	*	*	*	*	*	*	*	*	*	*
YOY white sucker	*	*	*	*	*	*	*	*					
Mt. sucker	*	*											
YOY channel catfish									*	*			*
Stonecat		*		*	*	*	*	*	*	*			*

Table 46 continued. Longitudinal distribution of forage fish species sampled in the middle Missouri River during the period from 1976 through 1980.

Fish Species	Morony Dam	Carter Ferry	Fort Benton	Loma Ferry	Coal Banks Landing	Hole-in-the-Wall	Judith Landing	Stafford Ferry	Cow Island	Robinson Bridge	Turkey Joe	Marias River	Teton River
YOY pumpkinseed				*									
YOY sm. bass					*								
YOY white crappie					*								
YOY yellow perch		*	*	*			*		*	*	*		
YOY sauger				*	*	*	*	*	*	*	*		
YOY walleye				*					*				
Iowa darter		*	*										
Freshwater drum											*		
Mottled sculpin	*	*		*		*				*			

1976). Although the creel census was not repeated in 1976, general observations suggested that fishing pressure and harvest remained high. Study efforts were, therefore, resumed on the research project in 1977.

The creel census study section consists of a 37-km reach of the Missouri River located immediately upstream from Fort Peck Reservoir. Harvest occurs by snagging, primarily in the spring as paddlefish migrate upstream from the reservoir. Typical snagging gear consists of a heavy surf-casting rod and reel, 13.6 - 36.3 kg (30-80 lb) test line, large treble hooks, and heavy weights. Occasionally, paddlefish are also caught in the summer and fall, but due to the low number taken in these seasons, only spring harvest was determined.

Creel Period and Coverage

Creel census efforts in 1977 began when the first paddlefish catch was reported on April 15 and extended through June 12 when most of the fishing activity had ceased and harvest rates dropped to a negligible level. Twenty-five (42.4 percent) of 59 days during the creel period were censused. Fishing pressure and harvest were greatest on weekend days and holidays, and 15 (88.2 percent) of 17 of these days were included in the census. During the census in 1979, 1,004 anglers were interviewed. Completed trip data were obtained on 81.3 percent of the anglers.

Fishing Pressure and Harvest

In 1977, an estimated 1,625 anglers fished 2,526 man-days (8,299 hours) and snagged 900 paddlefish (Table 47). The anglers harvested 666 (74.0 percent) of the fish caught, and the remainder were released. The overall catch rate averaged 0.36 fish/angler/man-day (0.11 fish/angler/hour) or .55 fish/angler/trip. Harvest rate averaged 0.26 fish/angler/man-day (0.08 fish/angler/hour) or 0.41 fish/angler/trip. The average length of a trip was 1.55 days in 1977, and the average angler spent 3.29 hours per day snagging.

The estimated total weight of the 1977 paddlefish catch in the Missouri River upstream from Fort Peck Reservoir was 21.17 metric tons (46,676 lb), with 15.96 metric tons (35,195 lb) of paddlefish harvested. By comparison the estimated harvest of paddlefish in the spring fishery on the Yellowstone River at Intake averaged 34.55 metric tons (76,169 lbs) annually during a 4-year period from 1972 to 1975 (Elser 1976). Estimated harvest from a fishery in the tailwaters of Big Bend Dam on the Missouri River in South Dakota averaged 47.10 metric tons (103,837 lbs) annually in 1970, 1971, and 1973 (Friberg 1974). Paddlefish harvest in a fishery on the Missouri River below Gavins Point Dam in South Dakota totaled 33.69 metric tons (74,273 lbs) in one snagging season (1972-73) during which a creel census was conducted. Prior to 1978, the largest sport fishery for paddlefish in the United States occurred in the Osage River above Lake-of-the-Ozarks in Missouri. Harvest during the two-month snagging season averaged about 90.72 metric tons (200,000 lbs) annually (Pflieger 1975). However, the Osage River fishery was drastically reduced with the closing of Truman Dam on the Osage River in 1978.

Bank anglers accounted for 56.6 percent (1,429 man-days) of the estimated fishing pressure during 1977, but they took only 48.3 percent of the paddlefish harvested for an average harvest rate of 0.23 paddlefish/angler/man-day (Table 47). Boat anglers accounted for 43.4 percent

Table 47. Estimates of fishermen, fishing pressure, total catch and harvest, and success rates during the spring snagging season on the paddlefish fishery above Fort Peck Reservoir, April 15 to June 12, 1977.

Statistic	Weekend-Holiday Stratum			Week Day Stratum			Entire Season		
	Bank	Boat	Total	Bank	Boat	Total	Bank	Boat	Total
Number of Fishermen	463	366	829	445	351	796	908	717	1,625
Fisherman Man-days	687	532	1,219	742	565	1,307	1,429	1,097	2,526
Fisherman Hours	2,245	2,074	4,319	2,334	1,646	3,980	4,579	3,720	8,299
No. Paddlefish Caught	215	197	412	233	255	488	448	452	900
No. Paddlefish Harvested	136	175	311	186	169	355	322	344	666
Fish Caught/Man-day	0.31	0.37	0.34	0.31	0.45	0.37	0.31	0.41	0.36
Fish Harvested/Man-day	0.20	0.33	0.26	0.25	0.30	0.27	0.23	0.31	0.26
Avg. Length of Trip (days)	1.48	1.45	1.47	1.67	1.61	1.64	1.57	1.53	1.55
Avg. Hours Fished/Day	3.27	3.90	3.54	3.15	2.91	3.05	3.20	3.39	3.29

(1,097 man-days) of the pressure and 51.7 percent of the harvest for an average harvest rate of 0.31 paddlefish/angler/man-day.

Weekend/holiday anglers accounted for 48.3 percent (1,219 man-days) of the estimated fishing pressure during 1977, but they took only 46.7 percent of the paddlefish harvested for an average harvest rate of 0.26 paddlefish/angler/man-day (Table 47). Weekday anglers accounted for 51.7 percent (1,307 man-days) of the pressure and 53.3 percent of the harvest for an average harvest rate of 0.27 paddlefish/angler/man-day.

Estimates of fishing pressure and paddlefish harvest for the 1977 snagging season are compared with 1973, 1974, and 1975 season estimates in Table 48. Fishing pressure and paddlefish harvest were higher in 1977 than during any of the previous creel census periods. Low water levels in the Missouri River during the snaggging season in 1977 may have been partly responsible for the increased angler pressure and harvest. A number of anglers interviewed felt that the low water conditions facilitated snagging of paddlefish. However, the overall angler success rate in 1977, in terms of paddlefish harvested/angler/man-day, was similar to previous years.

Angler Residency

Angler residence was obtained for 761 fishermen interviewed during the creel census period in 1977. Montana residents accounted for 97.2 percent of the anglers (Table 49). Paddlefish snaggers represented 61 Montana cities and towns with the dominant ones being Billings, Lewistown, and Great Falls. The same three cities dominated during previous creel censuses conducted in the study area (Needham 1973, 1975, and 1976).

Size and Sex Composition of Harvested Paddlefish

Length, weight, and sex data were obtained from 231 paddlefish harvested during the 1977 snagging season. The paddlefish examined were selected at random throughout the entire creel census period. Average length and weight of paddlefish harvested (males and females combined) was 154.9 cm (61.0 in.) and 25.2 kg (55.6 lb) (Table 50). Females averaged 168.9 cm (66.5 in.) and 35.5 kg (78.3 lb), while males averaged 145.0 cm (57.1 in.) and 17.9 kg (39.4 lb). The average size of male and female paddlefish harvested in 1977 was similar to the average size of fish harvested in seven previous years (Table 51).

Although the average female paddlefish harvested in 1977 outweighed the average male by a substantial margin, considerable overlap in weight/frequency of the two sexes was observed (Figure 27). Of the 231 paddlefish measured during the spring snagging season in 1977, 43.7 percent occurred in weight intervals which contained both male and female fish. The largest male paddlefish examined in the 1977 harvest weighed 38.1 kg (84 lb), while the smallest female weighed 22.2 kg (49 lb). Sex of these two fish was confirmed by autopsy and examination of gonads. Friberg (1974) also observed considerable overlap in weights of male and female paddlefish harvested in the tailwaters of Big Bend Dam on the Missouri River, South Dakota. The largest male in the Big Bend harvest weighed 29.5 kg (65 lb), while the smallest female weighed 15.9 kg (35 lb). Conversely, Elser (1976) and Rehwinkel (1975) observed no overlap in weight/frequency of male and female paddlefish harvested on the Yellowstone River at Intake, Montana.

Table 48. A summary of fishing pressure, paddlefish harvest and harvest rates during the spring snagging seasons on the paddlefish fishery above Fort Peck Reservoir, 1973-1975 and 1977.

Year	Total Fishermen Man-Days			Paddlefish Harvested			Harvest/Fisherman/Day		
	Bank	Boat	Total	Bank	Boat	Total	Bank	Boat	Overall
1973	984 (64.9%)	532 (35.1%)	1,516	290 (62.1%)	177 (37.9%)	467	0.29	0.33	0.31
1974	1,422 (63.1%	831 (36.9%)	2,253	396 (62.2%)	241 (37.8%)	637	0.28	0.29	0.28
1975	916 (61.8%)	566 (38.2%)	1,482	180 (46.7%)	205 (53.3%)	385	0.20	0.36	0.26
1977	1,429 (56.6%)	1,097 (43.4%)	2,526	322 (48.3%)	344 (51.7%)	666	0.23	0.31	0.26

Table 49. Angler residence for 761 fishermen interviewed during the paddlefish creel census period in 1977.

Montana Residents	Number of Fishermen	Montana Residents	Number of Fishermen
Billings	122	Helena	14
Lewistown	88	Kalispell	13
Great Falls	85	Winifred	13
Missoula	35	Stanford	12
Bozeman	25	Other Cities 1/	127
Butte	25		
Jordan	25	Resident Total	740
Laurel	23		
Malta	22	Nonresidents	
Park City	22	Wyoming	12
Grass Range	21	Idaho	6
Harlem	20	Washington	2
Roy	19	California	1
Havre	15		
Deer Lodge	14	Nonresident Total	21

1/ Cities in this category were each represented by 10 or less fishermen.

Table 50. Size of paddlefish harvested in the Missouri River above Fort Peck Reservoir during the spring of 1977.

	Number of Fish	Average Length 1/ (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Female	96	168.9	144.8 - 186.7	35.5	22.2 - 50.3
Male	135	145.0	118.1 - 174.0	17.9	4.5 - 38.1
Combined	231	154.9	118.1 - 186.7	25.2	4.5 - 50.3

1/ Length measurement is total length

Table 51. A summary of size data from paddlefish harvested in the Missouri River above Fort Peck Reservoir during eight spring snagging seasons, 1965 to 1977.

Year	Females			Males		
	Number of Fish	Average Length[1/] (cm)	Average Weight (kg)	Number of Fish	Average Length (cm)	Average Weight (kg)
1965	13	170.2	37.0	21	140.7	16.5
1966	36	162.6	33.7	30	135.4	14.6
1970	7	178.3	34.9	2	148.6	20.0
1971	10	169.4	38.9	1	144.8	20.0
1973	46	168.1	34.5	50	139.4	15.9
1974	58	165.9	33.8	67	139.7	14.9
1975	63	166.9	33.9	56	142.0	15.7
1977	96	168.9	35.5	135	144.5	17.8

1/ Length measurement is total length.

Table 52. A summary of paddlefish tagging and fisherman tag returns in the Missouri River above Fort Peck Reservoir, 1973 to 1977.

Year Tagged	Number of Fish Tagged	Number of Fish Harvested						Percent Harvested
		1973	1974	1975	1976	1977	Total	
1973	45	0	1	1	0	1	3	6.7
1974	55	-	3	0	1	1	5	9.1
1975	29	-	-	0	0	1	1	3.4
1976	23	-	-	-	1	1	2	8.7
1977	61	-	-	-	-	4	4	6.6
Total	213						15	7.0

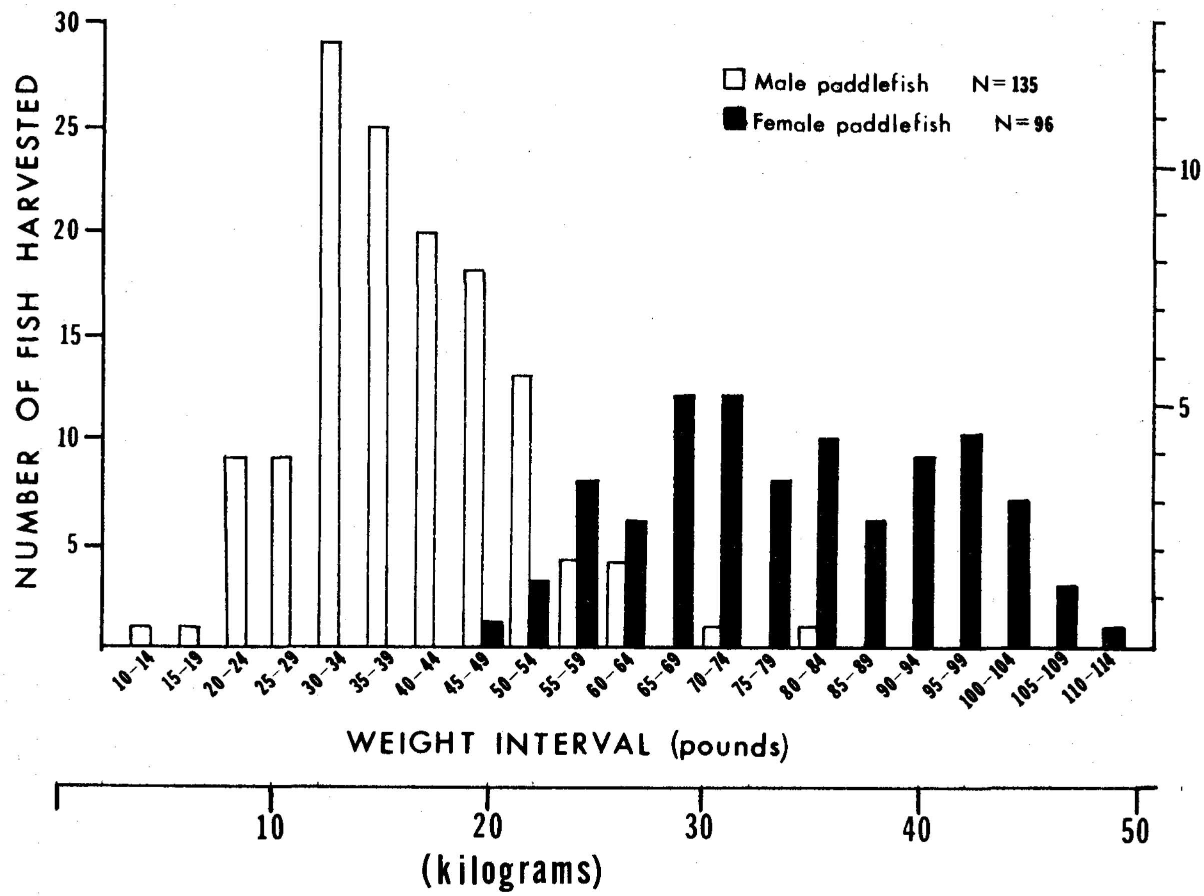


Figure 27. Weight-frequency and sex composition of 231 paddlefish harvested in the Missouri River above Fort Peck Reservoir during the spring of 1977.

Females accounted for 41.6 percent of the paddlefish examined in the 1977 harvest, while males comprised 58.4 percent. Since anglers often select for larger fish which are predominantly females, the observed sex ratio in the harvest may not be the sex ratio of the population.

Age Structure of Harvested Paddlefish

Dentary bones were collected from 142 paddlefish harvested during the 1977 snagging season to determine age structure of fish in the harvest. The dentary bones were collected at random throughout the entire creel census period, and the data, therefore, should be representative of the harvest. However, since anglers often select for larger fish which are usually older in age, the observed age structure of paddlefish in the harvest may not be representative of the age structure of the population.

Paddlefish ages were determined by cross-sectioning the dentary bones and "reading" the annuli in the mesial arm. Findings are presented in the age and growth section of this report.

Paddlefish Tagging

Sixty-one paddlefish were tagged during the spring migration season in 1977 with individually numbered, monel, poultry band tags anchored around the dentary bones to obtain information on angler harvest and movement. Paddlefish tagging assistance was provided by Mike Poore, Fisheries Division, Montana Department of Fish and Game, through Dingell-Johnson Project No. F-5-R-26, Job I-b. Of the fish collected for tagging, 13 were sampled by electrofishing, 44 were taken by snagging, and 4 were captured with large mesh gill nets drifted perpendicular to the current. All of the fish were captured in the Missouri River immediately upstream from Fort Peck Reservoir within the boundaries of the creel census study section. This brings the total number of paddlefish tagged and released since 1973 to 213. To date, 15 (7.0%) of the tags have been returned by anglers (Table 52). All of the recaptured fish were harvested in the creel census study section in the same area where they were tagged.

Discussion

Data collected in research studies conducted since 1965 suggest that the Missouri River/Fort Peck Reservoir paddlefish population is vigorous, and the current rate of exploitation by anglers does not appear excessive. The overall success rate of anglers in 1977, in terms of the number of paddlefish harvested/fisherman/man-day, was similar to previous years (Table 48). Also, the average size of male and female paddlefish harvested in 1977 was similar to previous years (Table 51). In addition, the total number of paddlefish harvested was higher in 1977 than during any of the previous years when creel censuses were conducted. If over-exploitation does occur in a paddlefish population, females would probably be affected first due to angler selection (Elser 1976).

With only 7.0 percent of the tagged fish returned by anglers, a low rate of harvest is indicated for the Missouri River/Fort Peck Reservoir paddlefish population. By comparison, 13.8 percent of 3,661 paddlefish tagged on the Yellowstone River at Intake since 1964 have been returned by anglers (Elser 1976). In data summarized by Carlander (1969), snagging by anglers brought tag return rates 9.8, 12.6, and 12.4 percent in several studies conducted in the tailwaters of Big Bend Dam on the Missouri River,

South Dakota. A tag return rate of 24.5 percent in three years following tagging of paddlefish on the Osage River, Missouri, was considered an excessive rate of exploitation (Purkett 1963). Angler harvest rates on the Missouri River/Fort Peck Reservoir paddlefish population do not approach this excessive rate. However, additional tagging of paddlefish and exposure of marked fish to the fishery, and further evaluation of angler success rates and size and sex composition of harvested fish will be necessary to properly evaluate the effects of exploitation rates on the Missouri River/Fort Peck Reservoir paddlefish population.

Potential habitat losses resulting from activities such as dam building or large-scale water withdrawals probably represent a greater threat to the Missouri River/Fort Peck Reservoir paddlefish population than over-exploitation by anglers. Every effort should be made to protect the middle Missouri River from this type of habitat alteration so the spawning migration can continue undiminished.

Missouri River Creel Survey

A creel survey was conducted from April, 1977, through August, 1978, on the Missouri River from Morony Dam to Fort Peck Reservoir. The most important game fish species present include sauger, walleye, northern pike, shovelnose sturgeon, channel catfish, burbot, and paddlefish. Since a separate creel census was conducted on paddlefish, this species was not included in this survey.

Results of 312 angler interviews indicated the average length of a fishing trip was 2.13 days, and the average angler spent 2.52 hours per day fishing (Table 53). Sauger comprised the greatest portion of the catch from Morony Dam to the Marias River, shovelnose sturgeon predominated from the Marias River to Robinson Bridge, and channel catfish were the most common species caught from Robinson Bridge to Fort Peck Reservoir. Anglers kept most game fish and released or discarded most nongame fish.

About 90 percent of the anglers interviewed were Montana residents. Only 1 percent of the anglers interviewed in the spring (mid-March to mid-June) were nonresidents compared to 19 percent in the summer (mid-June to mid-September). The nonresident anglers came from distant states, including New Jersey, Florida, Texas, Indiana, New Mexico, California, Missouri, and Minnesota, and from nearby states, including North Dakota, South Dakota, Wyoming, Idaho, Washington, Oregon, and the Canadian provinces of Alberta and Saskatchewan.

Angler Harvest as Indicated by Tag Returns

An indication of angler harvest of fish in the middle Missouri River was provided by angler-returned fish tags. Harvest estimates ranged from 0 percent for several species to 7.5 percent for northern pike and walleye (Table 54). Even though some anglers do not report tagged fish taken in their creel, the data indicate relatively light harvest rates for all species.

Only 0.5 percent of the shovelnose sturgeon tagged in the middle Missouri River were returned by anglers. On the lower Tongue River, Montana, anglers returned 1.1 percent of the shovelnose sturgeon tagged from 1974 through 1976 (Elser et al. 1977). Christenson (1975) reported 2.3 percent of shovelnose sturgeon tagged in the Red Cedar/Chippewa River

Table 53. A summary of creel survey data collected in three subreaches of the middle Missouri River during the spring and summer of 1977 and 1978.

Creel Survey Statistic	Subreach of Missouri River: Morony Dam - Marias River: Spring	Morony Dam - Marias River: Summer	Marias R. - Robinson Br.: Spring	Marias R. - Robinson Br.: Summer	Robinson Br. - Ft. Peck Res.: Spring	Robinson Br. - Ft. Peck Res.: Summer
No. of Fisherman Interviewed	33	40	10	134	69	26
Avg. Length of Trip (days)	1.61	3.06	1.70	2.41	1.54	2.46
Avg. Hrs. Fished/Day	1.83	1.66	1.72	2.81	4.03	3.04
Fish Caught/Man-hour 1/						
Sauger	0.46	0.35	0.19	0.10	0.14	0.00
Walleye	0.01	0.00	0.00	0.01	0.00	0.00
Shovelnose sturgeon	0.04	0.01	0.26	0.12	0.03	0.00
Channel catfish	0.04	0.01	0.19	0.13	0.07	0.11
Northern pike	0.00	0.03	0.00	0.00	0.01	0.02
Burbot	0.01	0.02	0.04	0.01	0.01	0.01
Other species	1.44	0.59	1.37	0.43	0.07	0.26
Fish Harvested/Man-hour 2/						
Sauger	0.46	0.32	0.19	0.09	0.14	0.00
Walleye	0.01	0.00	0.00	0.01	0.00	0.00
Shovelnose sturgeon	0.04	0.01	0.26	0.12	0.03	0.00
Channel catfish	0.03	0.01	0.19	0.12	0.07	0.09
Northern pike	0.00	0.03	0.00	0.00	0.00	0.02
Burbot	0.01	0.02	0.04	0.01	0.01	0.01
Other species	0.04	0.11	0.00	0.12	0.03	0.04
Percent of Fishermen who were Montana Residents	100	82	100	96	97	65

1/ Includes fish kept and fish released.
2/ Includes only fish kept.

Table 54. Summary of tagged fish returned (i.e., harvested) by anglers in the middle Missouri River from October 1, 1975 through October 1, 1980.

Species	No. of Fish Tagged	No. of Tags Returned by Anglers	Percent of Tags Returned
Pallid sturgeon	1	0	0
Shovelnose sturgeon	814	4	0.5
Mountain whitefish	131	0	0
Rainbow trout	18	0	0
Brown trout	28	1	3.6
Brook trout	2	0	0
Northern pike	40	3	7.5
Blue sucker	423	0	0
Smallmouth buffalo	287	3*	1.0
Bigmouth buffalo	97	1*	1.0
Channel catfish	1926	65	3.4
Burbot	169	1	0.6
White crappie	21	0	0
Yellow perch	2	0	0
Sauger	3950	58	1.5
Walleye	40	3	7.5
Freshwater drum	216	1	0.5

* Harvested by commercial fishermen in Fort Peck Reservoir.

system in Wisconsin were returned by anglers.

The current rate of exploitation of shovelnose sturgeon is not excessive. The shovelnose, like the lake sturgeon, is a slow-growing, late-maturing fish which cannot tolerate high levels of exploitation. Priegel (1973) believed lake sturgeon in the Menominee River, Wisconsin, could sustain a harvest rate of 5.0 percent without harm. The harvest rate for shovelnose sturgeon in the middle Missouri River is well below this level.

Anglers returned 1.5 percent of the sauger tagged in the middle Missouri River. Elser et al. (1977) reported 3.4 percent of the sauger tagged in the lower Tongue River, Montana, in 1976 were returned by anglers. On the lower Yellowstone River, Montana, a minimum harvest of 5 percent, based on angler tag returns, was reported for both walleye and sauger tagged from 1973 through 1977 (Graham et al. 1979).

Anglers returned 3.4 percent of the channel catfish tagged in the middle Missouri River. On the lower Tongue River, Montana, anglers returned 3.6 percent of the channel catfish tagged in 1975 and 1976 (Elser et al. 1977).

Fishing Seasons and Creel Limits

The fishing season in the middle Missouri River drainage is open from the third Saturday in May through November, with the exception of the Missouri River, Marias River, Judith River below its confluence with Big Spring Creek, Teton River below US Highway 89, Belt Creek below the bridge at Riceville, Big Spring Creek near Lewistown, and Musselshell River below the bridge at Barber which are open the entire year. Most lakes and reservoirs in the drainage are also open year round.

The daily and possession limits for fish in the study area are:

(1) Brown trout, cutthroat trout, rainbow trout, golden trout, lake trout and grayling - 10 pounds and 1 fish or 10 fish, whichever is reached first, in any combination.

(2) Brook trout - 10 pounds, no number limit.

(3) Bass, sauger, walleye - 10 in any combination.

(4) Northern pike - 5.

(5) Salmon - 10 with some restrictions listed in the regulations.

(6) Whitefish - 30 daily and 60 in possession.

(7) Paddlefish - 1 daily and 2 in possession.

There is no numeral limit on catfish, burbot, sturgeon, and nongame fish. However, the maximum weight of a sturgeon (genus *Scaphirhynchus*) which may be taken is 7.3 kilograms (16 pounds). This regulation was adopted statewide in Montana on May 1, 1980, to protect pallid sturgeon which are rare in the state. All sturgeon larger than 16 pounds are

assumed to be pallid sturgeon because shovelnose do not grow this large. The pallid sturgeon was designated as a threatened species in the United States in 1979 by the Endangered Species Committee of the American Fisheries Society (Holton 1980). This means the committee believes it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

There is no evidence that the fishing regulations outlined above have been detrimental to fish populations anywhere in the study area. In fact, fish populations in the area are lightly utilized, and fishing pressure for most species could probably be increased substantially without harming the populations. Paddlefish are probably an exception, and it is not recommended that harvest be increased substantially above current levels. Statewide limits on paddlefish, formerly two fish per day and in possession, were reduced in 1978 to one fish per day and two in possession to prevent overharvest. The DFWP will continue to monitor paddlefish and will be prepared to further reduce harvest if the future of paddlefish in Montana seems jeopardized (Holton 1980).

POTENTIAL AND EXISTING ENVIRONMENTAL PROBLEMS

The middle Missouri River and its tributaries support a fishery with substantial recreational value. A major threat to the resource is improper land and water use management. Water quality degradation and stream dewatering have had a detrimental impact on aquatic resources in some portions of the study area. In addition, increased exploitation of fossil fuel and nonfuel mineral resources in the drainage, threatened impoundment of the Missouri River near Fort Benton, and other possible water resource development projects could lead to future environmental problems.

Water Quality Degradation

Water quality in the middle Missouri River and its tributaries is considered generally good (US Congress 1975a). However, there are a few water quality problems in the drainage. A summary of the problems, as determined by the Water Quality Bureau of the Montana Department of Health and Environmental Sciences (DHES), is presented in Table 55.

Sediment is a water quality problem in several tributaries of the middle Missouri River (Kaiser and Botz 1975, Garvin and Botz 1975). The sediment originates largely from nonpoint sources in the Marias River, Judith River, and Arrow Creek drainages. Logging, agricultural, and urbanization practices, as well as natural sources, contribute to the problem.

Logging and urbanization activities in the headwaters of the Judith River and Big Spring Creek drainages near Lewistown have increased the stream sediment load to some extent in almost all portions of the middle Missouri River drainage. Agricultural sediment results mainly from irrigation return flows and erosion related to overgrazing, extensive monoculture, and clearing of vegetation from stream banks. Arrow Creek is the major natural source of sediment in the middle Missouri River basin (Kaiser and Botz 1975).

Table 55. A summary of water quality problems in the middle Missouri River drainage (adopted from inventories conducted by the Water Quality Bureau, Montana Department of Health and Environmental Sciences - Kaiser and Botz 1975, Garvin and Botz 1975).

Problem	Stream or Area	Status	Potential for Correction	Methods of Correction
Sediment, coliform, nutrient increases in streams due to livestock grazing, feedlots, irrigation returns and logging. (Severe in some areas.)	Big Spring Creek, Judith River, Ross Fork, Beaver Creek and other streams.	Little data available. Needs extensive survey and land use investigation. Problem probably increasing.	Poor to fair, Economical problem. Technical corrective measures available.	Relocation of feedlots, stream bank protection by fencing and plant cover. Increased efficiency of water use. Improved logging practices.
Increased salinity due to saline seeps. (Very severe problem.)	Arrow Creek, Coffee Creek, Big Spring Creek and many others	Problem increasing rapidly due to more intensive and changing land use. Some technical studies underway but far less than needed.	Poor to fair, Economics of land use involved. Technical corrective measures not well known.	Cropping practice changes; land use changes. Much more work needed on corrective measures.
Increased coliform, nutrient and BOD due to improper or nonfunctioning septic tank systems. (Moderately severe problem.)	Big Spring Creek near Lewistown	Poorly understood. Additional housing planned along stream. Needs intensive survey.	Good.	Correct improperly functioning tanks. Insure new tanks properly installed. Extend city sewage collection system.

Table 55 continued. A summary of water quality problems in the middle Missouri River drainage (adopted from inventories conducted by the Water Quality Bureau, Montana Department of Health and Environmental Sciences - Kaiser and Botz 1975, Garvin and Botz 1975.)

Problem	Stream or Area	Status	Potential for Correction	Methods of Correction
Increased nutrients and coliform concentrations from Lewistown sewage treatment plant. (Moderately severe problem.)	Big Spring Creek below plant.	Secondary treatment facility in planning stage.	Good.	Secondary treatment will improve effluent.
Organic loading, sludge due to disposal of saw mill wastes.	Big Spring Creek, Boyd Creek.	Corrective actions requested but little action to date. Problem not decreasing.	Good. Technical solution readily available.	Prevent drainage of lumber wastes into streams. Remove debris from stream banks.
Nutrient and organic loading from fish hatcheries	Big Spring Creek	Problem not well defined. More stringent effluent standards will be required in near future. Additional fish rearing planned.	Probably good. Problem not well defined.	Treatment of wastes. Additional work needed on problem and potential corrective measures.

Table 55 continued. A summary of water quality problems in the middle Missouri River drainage (adopted from inventories conducted by the Water Quality Bureau, Montana Department of Health and Environmental Sciences - Kaiser and Botz 1975, Garvin and Botz 1975.)

Problem	Stream or Area	Status	Potential for Correction	Methods of Correction
Chlorine ammonia, temperature from swimming pool discharge.	Big Spring Creek	Pool drained to creek periodically problem persistent.	Good.	Don't drain pool or drain to sewage system or use land for disposal (irrigation).
Ammonia toxicity from sewage lagoon wastes (moderately severe problem)	Little Dry Coulee and Dry Fork Marias R. (est. 5 miles of stream affected).	Continuing problem: needs further investigation	Good.	Reduce flow to stream by alternative wastewater use. Additional treatment.
High temperature, dewatering, salinity and nutrients from irrigation returns (moderately severe problem)	Teton River Spring Coulee to Loma (115 miles of stream affected).	Problem probably increasing due to more intensive land use. Needs an intensive survey.	Fair. Economically difficult problem. Technical corrective measures not defined	Better efficiency with irrigation water. Improved diversion scheduling. Needs additional investigation for correction methods.
Ammonia toxicity from sewage lagoon wastes (moderately severe problem).	Old Maid Coulee (est. 2 miles of stream affected).	Continuing problem; needs further investigation	Good.	Reduce flow to stream by alternative wastewater use. Additional treatment.

Table 55 continued. A summary of water quality problems in the middle Missouri River drainage (adopted from inventories conducted by the Water Quality Bureau, Montana Department of Health and Environmental Sciences - Kaiser and Botz 1975, Garvin and Botz 1975).

Problem	Stream or Area	Status	Potential for Correction	Methods of Correction
Increased salinity from saline seeps (severe problem).	Hilger Coulee Priest Butte L. Alkali Lake and other numerous areas.	Probably a rapidly increasing problem. Some work in progress but little corrective action to date.	Fair to poor.	Changes in cropping practices and land use. Much additional investigation needed to determine extent and possible solutions.
Excessive coliform due to sewage wastes from E. Glacier and E. Glacier Lodge (low severity).	Midvale Creek	Primary plant being replaced by a secondary plant. Secondary facility in planning stage.	Good.	Installation of secondary plant and coliform control in effluent.
Excessive turbidity and sediment from irrigation return flows (moderately severe).	Two Medicine Creek Highway.	Not known. Probably increasing as land and water use becomes more intensive.	Fair. Complex and economically important problem.	More efficient water use. Change cropping practices.

Suspended sediment in the Marias River is a concern in the upper portion of the drainage. The high sediment load in this area is probably due, in part, to natural instability of the streambeds and banks, but irrigation return flows add to the problem (Garvin and Botz 1975).

Nutrient enrichment of streams is a problem in some parts of the drainage. The nutrients enter the streams as a result of drainage from confined livestock yards, runoff from fertilized crop or pasture land, and substandard sewage treatment facilities. High concentrations of nutrients, particularly nitrates and phosphates, have caused serious eutrophication problems and depressed aquatic conditions in isolated portions of the Marias and Judith River drainages (Kaiser and Botz 1975, Garvin and Botz 1975).

Nutrient enrichment of the mainstem of the Missouri River from Great Falls to Coal Banks Landing was a problem prior to improvement of sewage treatment facilities at Great Falls and Fort Benton. A study conducted by the DHES on the Missouri River upstream from Fort Benton over a 3-day period in July, 1959, showed a coliform bacteria count in excess of 1,000/100 ml (US Congress 1975a). The high coliform count was attributed to inadequate municipal sewage treatment in the Great Falls area about 65 km upstream from Fort Benton. Similar tests near Coal Banks Landing, 70 km downstream from Fort Benton, still reflected the influence of sewage outfall from both Great Falls and Fort Benton. Both cities have substantially improved their sewage treatment plants since 1959, and a study conducted by the US Geological Survey in 1969 and 1970 revealed coliform bacterial counts within acceptable standards. Precautions should be taken to insure that any outfall released from sewage treatment facilities at Great Falls and Fort Benton remains within acceptable standards.

A great potential for water quality degradation and damage to aquatic life exists from saline seeps (Bahls and Miller 1973). Saline seep generally occurs throughout the middle Missouri River drainage, but it is unknown if any of the seep areas have been detrimental to aquatic life. Streams with saline seep problems in the study area include Bullwhacker, Dog, and Arrow creeks and portions of the Wolf Creek and Marias River drainages (Kaiser and Botz 1975, Garvin and Botz 1975).

Oil field exploration and development is a major activity in the Marias River drainage. Contamination of surface waters with oil can occur due to leakage at the drilling site or pipeline breaks. Oil contamination problems are presently confined to seeps from drill holes into some pothole lakes near Cutbank, Montana (Garvin and Botz 1975). Salt water, resulting from deep drilling operations, can also be an important pollutant. Continuous monitoring of oil development projects will be required to prevent increased water pollution.

In summary, water quality problems in the middle Missouri River drainage occur mainly in isolated portions of tributary streams. Water quality of the mainstem of the Missouri River has not been significantly impaired by these problems, and water quality in the drainage as a whole is good. However, efforts should be made to remedy the problems which exist, so that future problems can be avoided.

Water Use and Stream Dewatering

The largest user of water in the middle Missouri basin is agricultural irrigation, requiring an annual diversion of slightly more than 1.233 km^3/year [one million acre-ft/year (MAFY)]. Net depletion, including crop requirements, delivery loss, and evaporation, amount to about 0.6 km^3/year (0.5 MAFY). Slightly more than 0.6 km^3/year, or 53 percent of the total diversion, is eventually returned to the streams.

Municipal water use in the drainage amounts to less than 0.01 km^3/year (0.01 MAFY). Of this amount, about 30 percent is derived from surface water sources, and the remainder comes from groundwater. Other uses of water in the drainage (i.e. industrial and stock water) are negligible (Kaiser and Botz 1975, Garvin and Botz 1975).

During late summer and early fall, irrigation withdrawals leave portions of some tributaries dewatered. A comprehensive evaluation of dewatering on major streams was not made during this study; however, severe dewatering was observed in the lower Teton River, and moderately severe dewatering was observed in portions of the lower Judith River.

There are several possibilities for additional water depletion in the middle Missouri River basin. One recent study revealed the possibility of providing irrigation water for lands in the Milk River Valley by means of a 30 km (100 ft.) pump lift from the Missouri River near Virgelle, Montana. Water withdrawn from the Missouri River would be diverted through the preglacial channel of the Missouri River north of Virgelle and into Fresno Reservoir. Another diversion plan under study to provide irrigation water in the Milk River Valley would pump water from Fort Peck Reservoir through the Beaver Creek drainage in conjunction with the Fort Hawley Waterfowl proposal (US Congress 1975a).

The Missouri River between Morony Dam and Fort Benton contains several potential sites for hydropower dams. In addition, Montana Power Company has selected a site near Great Falls for a coal-fired generating plant.

The proposed hydropower dam, irrigation, and coal-fired generating plant projects have the potential to significantly alter the natural flow regime of the middle Missouri River. Consequently, detrimental effects on the aquatic ecosystem and existing recreational values may result. The extent of the impact depends on the magnitude and type of development. Impacts could be minimized by establishing a minimum instream flow regime sufficient to protect all existing uses. Instream flow levels required to maintain existing aquatic resources and recreational values of the Missouri River between Morony Dam and Fort Peck Reservoir have been determined (joint BLM/DFWP instream flow study, in press).

Exploitation of Fossil Fuel and Nonfuel Mineral Resources

Exploration and development of oil and natural gas fields in the middle Missouri River drainage has been increasing in recent years. The area lies within a geological province that is favorable for shallow (less than 2,000 ft.) natural gas accumulation. Within the last 6 years, four major natural gas fields have been designated south of the Bearpaw Mountains in the northcentral portion of the drainage. These are the

Sherard, Bullwhacker, Leroy, and Sawtooth Mountain fields. There are many shut-in wells outside of the four major fields, and there is a high probability that more producible wells will be drilled in other portions of the study area. Oil field development in the study area is currently confined mainly to the upper portion of the Marias River drainage. However, development of oil wells throughout the study area is possible.

Subbituminous coal deposits extend from the vicinity of Coal Banks Landing to the east boundary of the study area. Early in the century, small quantities of coal were mined and used domestically or sold commercially. Coal mining has been inactive in the study area for the past several decades, but the nation's energy problems could stimulate production (US Congress 1975a).

Bentonite beds lie in three shale formations in the study area. The beds of bentonite are generally less than 50 cm (18 in.) thick and covered by 15 to 30 m (50 to 100 ft.) of overburden. Because of the thick overburden, commercial development is not economically feasible at this time. However, analysis of samples has revealed that some of the bentonite beds are satisfactory for brick, while other are suitable for lightweight aggregate and possibly for foundry sand (USDI 1978).

Metallic minerals are relatively scarce in the study area, but a few known reserves are found in mountainous portions of the drainage. Although present production is negligible, increasing national demand for metallic minerals could stimulate development of the reserves.

Exploitation of the fossil fuel and nonfuel mineral resources described above could have a significant impact on the aquatic resource. Careful scrutiny of this activity will be required to prevent or minimize environmental degradation.

Development of natural gas and oil fields will probably require pipeline crossings of streams in the study area. The crossings must comply with all applicable stream preservation laws and water quality standards and should be routed through established utility and transportation corridors. Pipelines should not be allowed to cross through or in the immediate vicinity of the nine critical paddlefish spawning sites which have been identified.

Potential Hydropower Dams

The Missouri River between Morony Dam and Fort Benton contains several potential sites for hydropower dams ranging in magnitude from a high dam at Fort Benton with a 14.5-km afterbay (which backs water into the Wild and Scenic portion of the Missouri River) to major run-of-river dams (Table 56). Smaller pump-back storage dams on Highwood and Belt creeks, tributaries of the Missouri River between Morony Dam and Fort Benton, have also been studied but are not feasible because benefit/cost (B/C) ratios are presently well below unity. Potential dams on the mainstem of the Missouri River represent the greatest single threat to the aquatic resources of the study area.

The most obvious impact of the proposed dams would be the inundation of 11.3 to 64.4 km of the Missouri River and several km

Table 56. An evaluation of ten potential hydropower dam sites on the mainstem of the middle Missouri River between Fort Benton and Morony Dam (US Water and Power Resources Service appraisal study, September, 1980).

Dam	Location	Size and Type1/	B/C Ratio	River km Inundated	Elevation-meters2/ Reservoir	Afterbay
High Fort Benton and Afterbay	Just upstream from Ft. Benton, Afterbay 14.5 km downstream	360 MW Midrange	2.15	64.4	858.0	801.6
High Fort Benton	Just upstream from Ft. Benton	130 MW Baseload	1.37	50.7	858.0	-
High Carter and Afterbay (inundation Morony)	2.4 km upstream from Carter Ferry, Afterbay 11.3 km downstream	390 MW Midrange 27 MW Baseload (-49 MW)	1.79	45.1	883.9	821.4
New Morony and Afterbay (inundation Morony & Ryan)	1.6 km upstream from Morony Dam, Afterbay at Carter Site	466 MW Midrange 75 MW Baseload (-109 MW)	1.33	30.6	929.6	858.0
Low Carter and Afterbay	0.8 km upstream from Carter Ferry, Afterbay 9.7 km downstream	254 MW Midrange 34.5 MW Baseload	2.26	40.2	858.0	821.4
Low Carter	0.8 km upstream from Carter Ferry	75 MW Baseload	1.30	24.1	858.0	-
Tunis Run-of-River	5.6 km downstream from Carter Ferry	56 MW Baseload	1.11	21.7	835.2	-
Floweree Run-of-River	1.6 km upstream from Highwood Creek	60 MW Baseload	1.16	11.3	858.0	-
Floweree and Tunis	(see above)	116 MW Baseload	1.14	33.0	858.0	835.2

Table 56 continued. Water and Power Resources Service appraisal of ten hydropower dam sites on the mainstem of the middle Missouri River between Fort Benton and Morony Dam, September 1980.

Dam	Location	Size and Type 1/	B/C Ratio	River km Inundated	Elevation - meters 2/ Reservoir	Afterbay
Floweree and Afterbay at Tunis	(see above)	200 MW Midrange 48 MW Baseload	1.70	33.0	858.0	835.2

1/ Baseload has plant factor of 50 percent or greater, or 12 hours or more of operation per day. Midrange has a plant factor of 20 to 30 percent, or 5 to 7 hours of operation per day. Peaking has a plant factor from 10 to 15 percent, or 2.5 to 4 hours of operation per day.

2/ All elevations are water surface elevation behind the dams.

of tributary streams including the lower portions of Highwood Creek, Belt Creek, and possibly Shonkin Creek (Table 56). This irreversible commitment would inundate 3 to 19 percent of the 333-km reach of free-flowing Missouri River which currently remains between Morony Dam and Fort Peck Reservoir. This loss becomes particularly significant in light of increasing national demand for large, free-flowing recreational rivers combined with an ever-dimishing free-flowing stream resource.

The dams would be a barrier to fish migration. At least eight key fish species (sauger, walleye, shovelnose sturgeon, channel catfish, smallmouth and bigmouth buffalo, blue sucker, and brown trout) spawn in the Missouri River upstream from Fort Benton. In addition, goldeye, carp, and several species of suckers and minnows spawn here. Rainbow trout, mountain whitefish, and burbot probably spawn in this reach, but verification has not been made.

Tag return evidence indicates that fish using the Missouri River upstream from Fort Benton for spawning come for as far downstream as Fort Peck Reservoir, a distance of approximately 280 km. In addition, some species which normally reside in Fort Peck Reservoir also spawn upstream from Fort Benton. Tag return evidence indicates movements of these fish often exceed 300 km.

The fish movement barrier created by the dams would have a negative impact on the existing downstream sport fishery. Walleye, sauger, and brown trout and probably mountain whitefish, rainbow trout, and burbot depend heavily on the river upstream from Fort Benton for spawning. Spawning concentrations of these species were rarely found below Fort Benton, and it can be assumed that most of their spawning area would be inundated by the proposed dams. Since significant spawning concentrations of other species have been located below Fort Benton, their spawning areas would not be reduced as much by inundation. However, spawning of these species could be impacted by regulated flows and modification of habitat characteristics of the river below the dams.

The fish movement barrier created by the proposed dams could also negatively impact the commercial fishery in Fort Peck Reservoir. The three most important commercial fish species in the reservoir, goldeye, bigmouth buffalo, and smallmouth buffalo, spawn in the river above Fort Benton. Large concentrations of goldeye and buffalo were found in the area in electrofishing surveys conducted during the spawning period.

Less obvious, but perhaps even more significant, are possible downstream impacts of the proposed dams. Changes in flow regime, sediment transport, chemistry, and water temperature could cause adverse environmental impacts in downstream areas affecting species composition and abundance, channel configuration, and riparian habitat zones. A major concern about the dams is their possible effect on the paddlefish migration which occurs in the river immediately downstream from the proposed dams. The paddlefish is listed as a "Species of Special Concern - Class A" in Montana (Holton 1980), and any major encroachment on its remaining habitat must be avoided if the species is to survive.

At one time, paddlefish were common throughout much of the Mississippi/Missouri River system. However, during the last 100 years paddlefish numbers have declined considerably. A variety of man's influences have contributed to the demise of paddlefish, but dams, because they impeded upstream spawning migrations and destroy spawning grounds, have been the single most destructive factor (Pflieger 1975, Rehwinkel 1975, Vasetskiy 1971). Only six major self-sustaining paddlefish populations remain in the United States today, including the Missouri River/Fort Peck Reservoir population. A seventh major self-sustaining population was lost recently as a result of constructing Harry S. Truman Dam on the Osage River in Missouri. Natural reproduction of paddlefish in the Osage River was essentially eliminated with the closing of the dam in 1978 (Russell et al. 1980). An attempt is being made to maintain the Osage River population by artificial propagation, but the long-range success of this program is questionable.

Our studies indicate that a spring flow in excess of 396 m^3/sec (14,000 cfs) downstream from the US Geological Survey gage station on the Missouri River at Virgelle, Montana, is needed by paddlefish to reach critical spawning sites. The flow should exceed 396 m^3/sec for about 48 consecutive days from May 19 through July 5. Regulation of spring flow below the proposed dams could reduce paddlefish spawning runs. Spring flow in the Missouri River below Fort Benton has already been reduced to some extent by impoundment and storage at Canyon Ferry, Clark Canyon, Hebgen, Gibson, Hauser, Holter, and several other reservoirs in the Missouri River drainage upstream from Fort Benton. If spring flows are reduced further by additional dams, the spawning migration of paddlefish could be reduced or threatened.

Reservoirs behind the proposed dams would act as a sediment trap releasing relatively clear water with a high capacity to erode the streambed and banks. As a result, channel configuration of the river downstream from the dams would be altered. Any alteration of the nine critical paddlefish spawning sites between Fort Benton and Fort Peck Reservoir would be detrimental to paddlefish. Alteration of channel configuration has proven to be a substantial problem below other mainstem dams on the Missouri River.

Other potential impacts of the dams on paddlefish and other species could occur as a result of changes in water temperature, turbidity, and gas concentration. Paddlefish require water temperatures of at least 10 C (50 F) and moderately high turbidity during the spring runoff period for successful spawning. If the dams significantly alter these parameters, spawning and survival of paddlefish eggs and larvae would be impaired. Gas supersaturation has resulted in substantial kills of paddlefish and other fish species in the Osage River below Truman Dam in Missouri (Kim Graham, Missouri Department of Conservation, personal communication).

It is unlikely that self-sustaining populations of desirable sport fish species would be established in the reservoirs behind most of the proposed dams. Presently, there is a series of five hydropower reservoirs on the mainstem of the Missouri River in the vicinity of Great Falls, Montana, about 60 kilometers upstream from Fort Benton. These reservoirs do not support a substantial recreational fishery, even though they are close to Great Falls, Montana's second largest city.

Finally, construction of one or more of the proposed dams would result in a loss of recreational opportunities and scenic and aesthetic values, including loss of the last remaining "white water" segment of the Missouri. A study on distribution of recreationists on impounded and unimpounded sections of the lower Columbia and Snake rivers revealed that use of recreational boats per lineal mile of river was greatest on unimpounded reaches. With the addition of each impoundment on the Columbia and Snake rivers in the last several years, use by recreationists has shifted and intensified in the remaining unimpounded sections of river. Distribution data showed that recreationists prefer the unimpounded sections during all seasons (Holubetz and Simons 1975). With recreational use continuing to increase and already extensive on other free-flowing rivers in Montana, such as the Madison, Gallatin, Flathead, and Yellowstone, it becomes imperative to maintain this river in its natural state to continue to provide the unique aesthetic, fishing, and other recreational experiences it provides.

MANAGEMENT RECOMMENDATIONS

1. Nine paddlefish spawning sites have been identified on the mainstem of the middle Missouri River. The paddlefish is listed as a "Species of Special Concern - Class A" in Montana, and only six major self-sustaining populations remain in the United States. The paddlefish spawning sites are the most critical fish habitat type in the middle Missouri River. Every effort must be made to protect these sites so their use by paddlefish can continue undiminished.

2. Sediment is a water quality problem in portions of the middle Missouri River basin. Contributing factors include logging, agricultural, and urbanization practices as well as natural sources. The sediment problem is most severe in the Marias River, Judith River, and Arrow Creek drainages. Additional study is needed to better define the amount of sediment carried by these streams so that recommendations to control the problem can be formulated.

3. Nutrient enrichment of streams has caused severe eutrophication problems and depressed aquatic conditions in isolated portions of the Marias and Judith River drainages. In some cases, sewage or industrial waste treatment facilities should be upgraded to alleviate the problem. In other cases, confined livestock yards should be relocated to areas where animal wastes (i.e. nutrients) do not run directly into the streams.

4. The study area lies within one of the principal saline seep problem areas in Montana, and potential for water quality degradation exists. More study is needed to define the extent and causes of water pollution caused by saline seep so that recommendations to alleviate the problem can be formulated.

5. Extensive dewatering during the irrigation season seriously impairs fish populations in some streams in the study area. The problem is severe in the lower Teton River and moderately

severe in the lower Judith River. Since prior water rights are involved, little can be done to enhance or improve stream flows in severely dewatered areas. However, instream flow protection should be sought on streams in the study area to protect the aquatic resource from future dewatering problems. Streams of particular concern are the Marias, Teton, and Judith rivers and Belt and Highwood creeks.

6. There has been an increase in exploration and development of oil and natural gas fields in the middle Missouri River drainage. In addition, increasing national demand could stimulate exploration and production of coal, bentonite, and metallic mineral reserves located in the study area. Continuous monitoring of this activity and establishment of appropriate safeguards, where necessary, will be required to prevent loss of fish and wildlife habitat.

7. Development of natural gas and oil fields will probably require pipeline crossings of streams in the study area. All pipeline crossings should comply with applicable stream preservation laws and water quality standards. Crossings of the mainstem of the Missouri River should be routed through established utility and transportation corridors. Pipelines should not be allowed to cross through or in the immediate vicinity of the nine critical paddlefish spawning sites which have been identified.

8. Man-caused channel alterations are a problem in portions of the study area. Every effort should be made to ensure successful implementation of the Natural Streambed and Land Preservation Act of 1975 and the Stream Protection Act of 1963.

9. Development of one or more of the potential dam sites between Morony Dam and Fort Benton represents the greatest single threat to the aquatic resources of the middle Missouri River. Areas critical for reproduction and recruitment of several important fish species would be inundated. A major dam regulating spring flow could also have detrimental impacts on physical, chemical, and biological characteristics of the river below the dam. This would impair historic, aesthetic, and recreational values in the Wild and Scenic segment of the Missouri River. For these reasons every effort should be made to maintain the Missouri River in its free-flowing state.

LITERATURE CITED

Adams, L. A. 1942. Age determination and rate of growth in *Polyodon spathula*, by means of growth rings of the otiliths and dentary bone. Am. Mid. Nat. 28(3): 617-630.

American Public Health Association. 1975. Standard methods for the examination of water and waste water. New York. 769 pp.

Bahls, L. L. and M. R. Miller. 1973. Saline seep in Montana. Mont. Environmental Quality Council, Second Annual Rept.: 35-44.

Ballard, W. W. and R. G. Needham. 1964. Normal embryonic stages of *Polyodon spathula* (Walbaum). J. of Morph. 114(3): 465-478.

Barnickol, P. G. and W. C. Starrett. 1951. Commercial and sport fishes of the Mississippi River between Caruthersville, Missouri, and Dubuque, Iowa. Bull. Ill. Nat. Hist. Survey 25(5): 267-350.

Berg, R. K. 1975. Fish and game planning, Upper Yellowstone and Shields River drainages. Job Comp. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. FW-3-R. Job Ia. 92 pp.

__________. 1980. Spoonbill. Montana Outdoors 11(3): 11-13, 21-22.

Brown, C. J. D. 1971. Fishes of Montana. Endowment and Res. Found., Mont. St. Univ., Bozeman. 207 pp.

Brown, H. P. 1972. Aquatic dryopoid beetles (Coleoptera) of the United States. U.S. Envt. Prot. Agency Proj. No. 18050 ELD. Washington, D. C. 82 pp.

Carlander, K. D. 1969. Handbook of freshwater fishery biology. Iowa St. Univ. Press, Ames. 752 pp.

Carufel, L. H. 1963. Life history of sauger in Garrison Reservoir. J. Wildl. Mgmt. 27(3): 450-456.

Christenson, L. M. 1974. Notes on the blue sucker, *Cycleptus elongatus* (Lesueur) in the lower Chippewa and Red Cedar Rivers, Wisconsin. Wisc. Dept. Nat. Resc. Research Rept. No. 75. 7 pp.

__________. 1975. The shovelnose sturgeon, *Scaphirynchus platorynchus* (Rafinesque) in the Red Cedar - Chippewa River system, Wisconsin. Wisc. Dept. Nat. Resc. Research Rept. No. 82. 23 pp.

__________ and L. L. Smith. 1965. Characteristics of fish populations in upper Mississippi River backwater areas. Bur. of Sport Fish. and Wildl. Circ. No. 212. 53 pp.

Chu, S. P. 1942. The effect of the mineral composition of the medium on the growth of plankton algae. Jour. Ecol. 30: 284.

Cuerrier, J. 1951. The use of pectoral fin rays for determining age of sturgeon and other species of fish. Can. Fish. Cult. 11: 10-17.

Curry, J. J. and S. L. Wilson. 1955. Effect of sewage-borne phosphorus on algae. Sewage and Industrial Wastes 27: 1262.

Eddy, S. and T. Surber. 1943. Northern fishes, with special reference to the Upper Mississippi Valley. Univ. of Minn. Press, Minneapolis. 276 pp.

Elser, A. A. 1976. Southeast Montana fisheries investigations. Job Prog. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. F-30-R-12. Job Ia. Paddlefish investigations. 12 pp.

__________, R. C. McFarland and D. Schwehr. 1977. The effect of altered streamflow on fish of the Yellowstone and Tongue rivers, Montana. Tech. Rept. No. 8, Yellowstone Impact Study. Water Resources Div., Mont. Dept. of Nat. Resources and Cons., Helena. 180 pp.

FAO. 1975. Symposium of methodology for the survey, monitoring, and appraisal of fishery resources in lakes and large rivers. 747 pp.

Friberg, D. V. 1974. Investigations of paddlefish populations in South Dakota and development of management plans, 1973. Job Prog. Rept., Proj. No. F-15-R-8, S. Dak. Dept. of Game, Fish and Parks. 33 pp.

Gardner, W. M. and R. K. Berg. 1981. An analysis of the instream flow requirements for selected fishes in the Wild and Scenic portion of the Missouri River. Mont. Dept. of Fish, Wildlife, and Parks. In press.

Garvin, W. H. and M. K. Botz. 1975. Water quality inventory and management plan, Marias River basin, Montana. Water Quality Bureau, Mont. Dept. of Health and Envt. Sciences, Helena. 118 pp.

Gieseker, L. F. 1931. Soils of Choteau County. Mont. Agr. Exp. Stat. Bull. No. 252.

Graham, P. J. and R. F. Penkal. 1978. Aquatic environmental analysis in the lower Yellowstone River. Mont. Dept. of Fish and Game. 102 pp.

__________, R. F. Penkal and L. G. Peterman. 1979. Aquatic studies of the Yellowstone River. Mont. Dept. of Fish and Game study. US Bur. of Rec. Tech. Rept. No. REC-ERC-79-8. 80 pp.

Haddix, M. H. and C. C. Estes. 1976. Lower Yellowstone River fishery study. Final Rept., Mont. Dept. of Fish and Game. 81 pp.

Helms, D. R. 1973. Progress report on the second year of study of shovelnose sturgeon in the Mississippi River. Annual Prog. Rept., Proj. No. 2-156-R-1, Iowa Cons. Comm. 33 pp.

__________. 1973. Progress report from the first year study of sub-legal sized channel catfish in the Mississippi River. Job Prog. Rept., Proj. No. 2-178-R-1, Iowa Cons. Comm. 57 pp.

__________. 1974a. Shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the navigational impoundments of the upper Mississippi River. Iowa Cons. Comm., Fish. Tech. Series No. 74-3. 68 pp.

__________. 1974b. Age and growth of shovelnose sturgeon, *Scaphirhynchus platorynchus*, in the Mississippi River. Proc. Iowa Acad. Sci. 81(2): 73-75.

__________. 1975. Variations in the abundance of channel catfish year classes in the upper Mississippi River and causative factors. Iowa Cons. Comm. Fish. Tech. Series No. 75-1. 31 pp.

Hogue, J. J., R. Wallus and L. K. Kay. 1976. Preliminary guide to the identification of larval fishes in the Tennessee River. TVA, Norris, Tenn. 66 pp.

Holton, G. 1980. The riddles of existence: Fishes of "special concern." Montana Outdoors 11(1): 2-6, 26.

Holubetz, T. and R. Simons. 1975. Unimpounded river preference. Sport Fishing Inst. Bull. No. 264. May 1975.

Hornung, C. E. and G. E. Pollard. 1978. Macroinvertebrate sampling techniques for streams in semi-arid regions: Comparison of the Surber method and a unit-effort traveling kick method. Envt. Prot. Agency Rept. No. 600/4-78-040. 21 pp.

Hubley, R. C. Jr. 1963. Movement of tagged channel catfish in the upper Mississippi River. Trans. Am Fish. Soc. 92: 165-168.

Hynes, H. B. N. 1970. The ecology of running waters. Univ. of Toronto Press. 555 pp.

Kaiser, J. and M. K. Botz. 1975. Water quality inventory and management plan, middle Missouri River basin, Montana. Water Quality Bureau, Mont. Dept. of Health and Envt. Sciences, Helena. 89 pp.

Kallemeyn, L. W. and J. F. Novotny. 1977. Fish and food organisms in various habitats of the Missouri River in South Dakota, Nebraska, and Iowa. US Fish and Wildl. Ser. Rept. No. FWS/OBS-77/25. 100 pp.

Lagler, K. F. 1956. Freshwater fishery biology. Wm C. Brown Pub. Co., Dubuque, Ia. 421 pp.

Livingstone, D. A. 1963. Chemical composition of rivers and lakes. *In* Data of geochemistry (6th ed.). US Geol. Survey Prof. Paper 440-G: G1-G64.

Marzolf, R. C. 1955. Use of pectoral spines and vertebrae for determining age and rate of growth of the channel catfish. J. Wildl. Mgmt. 19(2): 243-249.

May, E. B. and C. R. Gasaway. 1967. A preliminary key to the identification of larval fishes of Oklahoma with particular reference to Canton Reservoir, including a selected bibliography. Okla. Fish. Res. Lab., Bull. 5, Contr. No. 164. Okla. Dept. Wildl. and Cons., Norman. 42 pp.

Merritt, R. W. and K. W. Cummins. 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Pub. Co., Dubuque, Ia. 441 pp.

Meyer, F. P. 1960. Life history of *Marsipometra hastata* and the biology of its host, *Polyodon spathula*. PhD thesis, Ia. St. Univ., Ames. 145 pp.

Missouri River Joint Study. 1963. Joint report on water and related land resources development by the US Corps of Engineers and the Bureau of Reclamation. 60 pp.

Monson, M. A. and J. Greenbank. 1947. Size and maturity of hackle-back sturgeon. Upper Mississippi R. Cons. Comm. Tech. Commit. Fish Prog. Rept. 3: 42-45.

Moos, R. E. 1978. Movement and reproduction of shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the Missouri River, South Dakota. PhD thesis, Univ. of S. Dak., Vermillion. 213 pp.

Morris, L. A. 1965. Sauger and walleye invesigations in the Missouri River. Job Comp. Rept., Proj. No. F-4-R-10, Nebr. Game and Parks Comm. 7 pp.

__________. 1969. Sauger and walleye investigations in the Missouri River. Job Comp. Rept., Proj. No. F-4-R-15, Nebr. Game and Parks Comm. 9 pp.

Morris, J., L. Morris and L. Witt. 1974. The fishes of Nebraska. Nebr. Game and Parks Comm. 98 pp.

Needham, R. G. 1973. Northeast Montana fisheries investigation. Job Prog. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. F-11-R-20. Job IIa. 5 pp.

__________. 1975. Northeast Montana fisheries investigation. Job Prog. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. F-11-R-22. Job IIa. 6 pp.

__________. 1976. Northeast Montana fisheries investigation. Job Prog. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. F-11-R-23. Job IIa. 6 pp.

__________. 1978. Missouri River - Fort Peck Reservoir paddlefish study. Mont. Dept. of Fish and Game. 19 pp.

Nelson, W. R. 1968. Reproduction and early life history of sauger, *Stizostedion canadense*, in Lewis and Clark Lake. Trans. Am. Fish. Soc. 97(2): 159-166.

Newell, R. L. 1976. Yellowstone River study. Mont. Dept. of Fish and Game. 97 pp.

Novotny, D. W. and G. R. Priegel. 1974. Electrofishing boats - improved designs and operational guidelines to increase the effectiveness of boom shockers. Wisc. Dept. Nat. Resc. Tech. Bull. No. 73. 48 pp.

Pennak, R. W. 1953. Fresh water invertebrates of the United States. The Ronald Press Co., N. Y., N. Y. 769 pp.

Peterman, L. G. 1978. Electrofishing large rivers - the Yellowstone experience. Paper presented at: The electrofishing workshop, St. Paul, Minn., March 9-10, 1978.

__________ and M. H. Haddix. 1975. Lower Yellowstone River fishery study. Prog. Rept. No. 1, Mont. Dept. of Fish and Game. 56 pp.

Peters, J. C. 1964. Age and growth studies and analysis of bottom samples in connection with pollution studies. Job Comp. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. F-23-R-6. Job I and II. 76 pp.

Pflieger, W. L. 1975. The fishes of Missouri. Missouri Dept. of Cons., Jefferson City, Mo. 343 pp.

Posewitz, J. A. 1962. A fish population investigation in the Marias River below Tiber Dam. Fed. Aid to Fish and Wildl. Rest. Proj. No. F-5-R-11. Job IIa. 9 pp.

__________. 1963. Missouri River fish population study. Fed. Aid to Fish and Wildl. Rest. Proj. No. F-11-R-10. Job III. 9 pp.

Priegel, G. R. 1969. The lake Winnebago sauger. Wisc. Dept. Nat. Resc. Tech. Bull. No. 43. 63 pp.

__________. 1973. Lake sturgeon management on the Menominee River. Wisc. Dept. Nat. Resc. Tech. Bull. No. 67. 20 pp.

Purkett, C. A. 1957. Growth of the fishes in the Salt River, Missouri. Trans. Am. Fish. Soc. 87: 116-131.

__________. 1961. Reproduction and early development of the paddlefish. Trans. Am. Fish. Soc. 90(2): 125-129.

__________. 1963. The paddlefish fishery of the Osage River and Lake of the Ozarks, Missouri. Trans. Am. Fish. Soc. 92(3): 239-244.

Ragland, D. V. and J. W. Robinson. 1972. Dynamics and growth of commercially exploited catfish populations in the lower Missouri River. Final Rept., Nat. Marine Fisheries Ser., Proj. No. 4-3-R, Missouri Dept. of Cons. 39 pp.

Rehwinkel, B. J. 1975. The fishery for paddlefish at Intake, Montana during 1973 and 1974. M. S. thesis, Mont. St. Univ., Bozeman. 37 pp.

__________, M. Gorges and J. Wells. 1976. Powder River aquatic ecology project. Annual Rept., Oct. 1, 1975-June 30, 1976. Mont. Dept. of Fish and Game. 35 pp.

Reid, G. K. 1961. Ecology of inland waters and estuaries. Van Nostrand Rienhold Company, New York. 375 pp.

Ricker, W. E. 1971. Methods for assessment of fish production in fresh waters. IBP handbook no. 3. Blackwell Scientific Pub., Oxford and Edinburgh, England. 348 pp.

Riggs, V. L. 1978. Age and growth of walleye and sauger of the Tongue River Reservoir, Montana. M. S. thesis, Mont. St. Univ., Bozeman. 53 pp.

Robinson, J. W. 1973. Missouri River habitat study. Final Rept., Proj. No. 4-3-R-8, Missouri Dept. of Cons. 15 pp.

__________. 1977. The utilization of dikes by certain fishes in the Missouri River. Final Rept., Proj. No. 2-199-R, Missouri Dept. of Cons. 17 pp.

Roemhild, G. 1976. The aquatic Heteroptera (True Bugs) of Montana. Mont. Agr. Exp. Stat. Research Rept. No. 102. 70 pp.

Roussow, G. 1957. Some considerations concerning sturgeon spawning periodicity. J. Fish. Res. Bd. Can. 14(4): 553-572.

Russell, T. R., L. K. Graham, D. M. Carlson and E. J. Hamilton. 1980. Maintenance of the Osage River - Lake of the Ozarks paddlefish fishery. Missouri Dept. of Cons. 33 pp.

Sawyer, C. N. 1948. Fertilization of lakes by agricultural and urban drainage. Water Pollution Abs. 21, April 1948.

Schmulbach, J. C. 1974. An ecological study of the Missouri River prior to channelization. Comp. Rept., Proj. B-024-S. Univ. of South Dakota, Vermillion. 34 pp.

Schwehr, D. J. 1977. Temperature related zonation of aquatic insects in the Yellowstone River. Mont. Dept. of Fish and Game. 23 pp.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. of Canada, Ottawa. 966 pp.

Sneed, K. E. 1951. A method for calculating the growth of channel catfish, *Ictalurus lacustris punctatus*. Trans. Am. Fish. Soc. 80: 174-183.

Stuckey, N. P. 1973. Effects of warm water discharges on fish in the Missouri River. Job Prog. Rept., Proj. No. F-4-R-18, Nebr. Game and Parks Comm. 14 pp.

Tesch, F. W. 1971. Age and growth. *In* Methods for assessment of fish production in fresh waters. IBP handbook no. 3. Blackwell Scientific Pub., Oxford and Edinburgh, England. 348 pp.

Trautman, M. B. 1957. The fishes of Ohio. Ohio St. Univ. Press. 683 pp.

US Congress. 1975a. Hearings on S. 1506, a bill to amend the wild and scenic rivers act, part 2 - Missouri River, Mont. US Govt. Printing Office, Washington, D. C. 444 pp.

__________. 1975b. Designating a segment of the Missouri River in the state of Montana as a component of the national wild and scenic rivers system. Senate Rept. No. 94-502. 16 pp.

USDI. 1975. Missouri River - A wild and scenic river study. Bur. of Outdoor Rec. 95 pp.

__________. 1978. Upper Missouri wild and scenic river management plan. Supplemental document (final). Bur. of Land Mgmt. 159 pp.

USGS. 1979. Water resources data for Montana. US Dept. of Interior. 824 pp.

__________. 1980. Flow duration hydrograph for Missouri River at Virgelle, Montana, 39-year period between water years 1940 and 1978.

US Water and Power Resources Service. 1980. Fort Benton reformulation newsletter, issue 2, Sept. 1980. 3 pp.

Unkenholz, D. G. 1980A. Investigation of the paddlefish population and recruitment in the Missouri River below Gavins Point Dam. Job Prog. Rept., Proj. No. F-15-R-15, S. Dak. Dept. of Game Fish and Parks. 7 pp.

__________. 1980b. Paddlefish spawning movements and reproductive success in the Missouri River below Fort Randall Dam, 1979. Prog. Rept. No. 80-3, S. Dak. Dept. of Game, Fish and Parks. 13 pp.

Vasetskiy, S. G. 1971. Fishes of the family Polyondontidae. Jour. of Icthyology 11(1): 18-31.

Ward, H. B. and G. C. Whipple. 1959. Fresh water biology. John Wiley and Sons, Inc., New York, N. Y. 1248 pp.

Wiedenheft, B. 1980. South central fisheries investigation/Musselshell River study. Job Prog. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. F-20-R-24. Job Ia (supplement). 15 pp.

Wipperman, A. H. 1973. Smith River drainage inventory and planning investigation. Job Comp. Rept., Fed. Aid to Fish and Wildl. Rest. Proj. No. FW-1-R, Job Ia.

Witt, A. Jr. 1961. An improved instrument to section bones for age and growth determinations of fish. Prog. Fish - Cult. 23(2): 94-96.

Zweiacker, P. L. 1967. Aspects of the life history of the shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the Missouri River. M. A. thesis, Univ. of S. Dak., Vermillion. 46 pp.

Appendix Table 1. River distance chart for the middle Missouri River study area. Confluence of the Missouri River with the normal flood pool of Fort Peck Lake is river kilometer 0.0.

Location	River Kilometer
Morony Dam	333
Belt Creek	331
Highwood Creek	321
Carter Ferry	307
Fort Benton	281
Loma Ferry	248
Marias River	245
Spanish Island	235
Virgelle Ferry	218
Coal Banks Landing	213
Little Sandy Creek	205
Eagle Creek	190
Hole-in-the-Wall	177
Arrow Creek	154
Judith River	138
Judith Ferry	136
Stafford Ferry	114
Bird Rapids	92
Sturgeon Island	85
Cow Island	70
Grand Island	51
Robinson Bridge	37
Slippery Ann Campground	28
Rock Creek	16
Turkey Joe	1
Fort Peck Reservoir	0

Appendix Table 2. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Morony Dam during 1977.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1							56	62	61	68	54	59		
2							59	63	62	67	52	59		
3							55	61	61	64	56	61		
4							55	59	59	63	56	63		
5							56	63	59	63	59	63		
6						66	58	61	59	63	56	63		
7					60	67	56	60	59	65	55	63		
8					60	67	55	63	59	65	57			
9					63	67	56	62	60	62				
10					58	61	57	58	58	63				
11					57	58	56	62	53	63				
12					56	60	58	64	58	64				
13					55	62	58	60	60	61				
14					57	62	56	62	60	61				
15					57	62	63	65	57	60				
16					56	60	58	66	58	63				
17					56	63	60	64	57	65				
18					56	64	61	66	59	65				
19					57	63	62	65	61	65				
20					58	64	59	65	63	65				
21					59	65	60	67	61	65				
22					58	64	62	68	62	63				
23					57	65	62	67	60	65				
24					59	65	62	65	59	64				
25					58	67	59	61	56	62				
26					59	65	61	66	54	60				
27					63	65	61	67	55	59				
28					56	60	62	68	52	59				
29					58	60	62	66	56	60				
30					53	63	60	61	55	58				
31							59	64	53	58				

Appendix Table 3. Daily maximum and minimum water temperatures (degrees F) for the Missouri River at Fort Benton during 1976.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1			46	52	57	61	64	68	68	73	64	70	59	63
2			49	53	58	61	63	67	69	73	66	71	60	63
3			50	54	57	61	63	70	69	74	65	70	59	61
4			51	52	58	60	65	69	69	73	65	69	57	60
5			50	51	57	60	65	70	69	74	65	70	54	56
6			49	51	57	60	65	72	68	74	63	68	53	57
7			48	52	58	59	66	72	68	72	61	64	52	56
8			50	53	57	60	67	72	67	73	60	65	52	56
9			52	56	57	62	66	70	67	72	59	64	53	57
10			54	57	58	64	66	70	68	73	59	64	53	57
11			53	56	61	64	65	71	67	73	59	62	54	58
12			52	54	60	63	66	71	68	72	60	63	54	58
13			52	54	57	60	66	71	67	72	59	64	54	57
14			53	54	57	60	67	72	66	70	59	64	52	54
15		52	52	55	56	61	68	72	65	72	60	65	50	52
16	49	50	52	54	57	69	67	73	66	70	60	66	48	50
17	47	49	52	56	57	59	68	73	65	70	62	66	47	49
18	46	49	54	56	56	62	70	71	63	67	62	65	47	50
19	45	49	54	57	57	64	69	72	64	69	59	64	45	48
20	45	49	54	57	60	65	68	74	64	68	58	63	46	49
21	45	49	54	58	61	66	67	72	63	70	58	63	45	48
22	45	48	55	58	62	64	67	73	64	70	58	62	46	48
23	46	49	56	59	58	61	67	74	67	68	59	63	45	47
24	47	52	56	60	57	60	68	74	66	72	60	63	44	46
25	47	49	57	59	56	57	67	75	66	72	61	64	45	47
26	45	47	56	59	55	59	68	75	65	67	61	65	46	49
27	43	45	56	60	55	60	69	74	62	67	59	63	46	49
28	42	43	57	59	58	63	68	73	62	67	58	63	47	50
29	42	46	57	60	60	66	68	74	62	68	59	63	47	49
30	43	50	57	60	62	67	67	73	63	69	59	63	46	48
31			57	60			68	74	63	70			46	47

Appendix Table 4. Daily maximum and minimum water temperatures (degrees F) for the Missouri River at Fort Benton during 1977.

	April		May		June		July		Aug.		Sept.		Oct.	
Day	Min.	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	36	41	53	57			65	72	68	75	58	63	52	53
2	36	41	54	59			64	70	69	74	57	63	51	56
3	36	40	55	59			64	73	68	71	60	65	51	54
4	40	45	52	56			63	67	66	70	61	68	49	54
5	41	47	51	55	41	47	63	71	66	70	63	69	48	51
6	42	48	51				57	68	66	70	62	68	48	52
7	44	50					57	67	66	72	62	68	50	51
8	46	53					63	71	65	72	61	65	47	51
9	49	53					65	71	64	69	59	65	47	49
10	48	52		61			63	65	62	70	61	67	45	48
11	48	52	54	59			61	70	64	71	60	65	45	49
12	47	53	55	61			66	72	65	69	59	65	46	51
13	47	53	56	62			64	68	65	68	62	65	48	51
14	48	51	58	62		68	64	73	63	72	60	65	47	50
15	47	52	55	56	62	67	66	72	64	71	60	63	47	52
16	49	54	54	57	62	67	66	78	64	68	59	61	49	54
17	42	53	52	55	61	73	63	71	63		58	59	49	53
18	43	52	50	53	63	70	67	71			57	62	49	53
19	47	50	49	51	65	70	68	74			57	62	50	53
20	47	51	49	54	63	71	66	71	67	70	57	62	50	53
21	45	50	50	55	67	74	67	75	66	72	57	62	49	52
22	47	54	51	58	68	74	70	77	66	70	56	60	49	52
23	47	53	54	60	67	74	71	77	65	71	54	59	49	53
24	46	56	57	59	69	73	70	75	66	69	55	57	49	51
25	49	57	57	59	69	74	67	70	62	68	53	58	49	51
26	54	59	56	64	69	74	69	75	65	67	54	59	48	50
27	54	59	58	60	68	72	69	76	61	64	53	57	45	50
28	54	59	53	59	65	72	70	77	59	64	54	56	47	50
29	55	59			63	67	70	75	60	63	54	55	47	49
30	55	60			62	74	68	70	59	60	53	55	46	49
31							67	73	57	64			44	47

Appendix Table 5. Daily maximum and minimum water temperatures (degrees F) for the Missouri River at Fort Benton during 1978.

	April		May		June		July		Aug.		Sept.		Oct.	
Day	Min.	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	36	40	50	56	51	55	65	68	67	69	63	67	52	57
2	37	42	50	55	53	56	65	68	67	70	64	67	52	56
3	36	41	50	53	56	58	63	66	68	71	64	68	50	54
4	37	41	49	53	59	63	62	65	66	69	63	68	50	54
5	38	42	48	52	60	64	61	64	66	70	64	67	51	54
6	39	42	48	51	60	64	60	62	67	72	64	68	51	56
7	41	43	47	50	60	64	59	62	68	73	63	68	51	55
8	42	44	46	50	60	64	59	62	69	74	63	67	50	55
9	42	48	48	51	60	63	61	65	69	73	62	66	50	56
10	43	51	49	52	60	63	62	66	69	73	61	63	49	54
11	41	50	48	52	59	62	62	66	69	72	58	61	51	54
12	43	49	50	53	56	60	63	66	68	72	55	56	50	53
13	43	49	50	54	57	60	64	67	66	70	53	55	48	52
14	43	47	51	54	58	61	65	68	65	69	53	57	48	53
15	43	48	52	55	59	62	65	69	64	67	54	58	48	52
16	45	49	53	56	60	63	66	70	62	66	53	56	48	52
17	43	47	52	55	61	64	66	67	60	64	53	55	49	53
18	44	48	51	53	59	62	64	66	61	64	51	53	49	52
19	46	49	51	55	58	60	65	67	60	64	50	54	48	51
20	45	48	52	56	59	62	65	68	59	63	51	55	48	53
21	46	48	53	57	60	64	65	69	60	64	50	56	47	50
22	45	49	55	59	62	66	65	70	61	65	50	55	48	52
23	44	48	54	58	62	67	65	70	60	66	52	57	47	51
24	46	49	53	56	63	68	66	71	62	68	53	58	46	50
25	46	50	52	55	62	64	68	73	62	67	54	60	46	50
26	47	51	54	58	62	65	69	74	61	66	54	59	45	48
27	47	53	57	60	62	65	69	74	61	66	54	58	44	46
28	49	55	54	57	63	66	68	73	62	68	53	58	45	47
29	48	54	56	60	64	67	69	73	63	68	53	58	45	46
30	50	56	58	61	65	67	69	73	64	69	53	58	44	46
31			55	58			69	73	63	68			44	46

Appendix Table 6. Daily maximum and minimum water temperatures (degrees F) for the Missouri River at Fort Benton during 1979.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1			53	55	52	57	63	71	68	75	65	68	55	57
2			52	57	54	59	65	70	69	76	65	69	56	57
3			51	54	58	62	63	70	69	75	64	70	52	57
4			51	53	57	61	64	67	69	75	64	67	53	56
5			52	53	58	61	65	71	70	77	62	68	54	57
6			52	53	58	60	66	73	69	76	62	68	53	58
7			50	53	55	56	67	75	69	76	64	68	56	60
8			49	51	54	57	69	73	69	76	64	69	54	55
9			50	53	55	57	68	75	68	74	64	67	52	56
10			49	56	56	58	71	72	68	74	63	64	53	57
11			52	55	58	65	71	72	69	71	61	64	55	57
12			52	56	61	67	68	72	67	72	62	64	54	57
13			54	58	66	67	66	72	66	69	61	65	52	57
14			55	62	63	67	69	70	63	70	60	63	53	57
15			57	63	61	66	65	73	66	72	61	64	55	56
16			59	62	61	63	65	72	65	71	63	65	54	57
17			57	59	62	67	70	74	66	73	61	65	53	55
18			55	57	62	67	69	76	68	72	61	66	50	52
19			54	58	61	62	70	77	68	71	61	65	49	51
20			52	56	60	63	71	77	68	72	61	65	45	47
21			53	57	59	63	72	79	68	70	61	64	46	47
22			54	57	60	65	73	77	67	73	60	65	46	48
23			54	60	61	67	70	74	67	72	60	64	46	49
24			57	60	62	67	69	73	67	68	59	64	45	48
25		52	57	62	63	69	65	69	65	69	59	64	46	48
26	47	50	57	63	65	72	67	72	66	71	61	65	47	50
27	48	55	58	61	67	72	67	73	65	70	59	63	46	48
28	50	57	57	59	68	75	67	72	64	70	59	62	46	49
29	52	56	55	57	68	73	66	72	65	71	57	62	46	48
30	52	57	53	57	71	74	68	73	65	71	58	59	44	47
31			52	57			68	75	65	68			43	45

Appendix Table 7. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Coal Banks Landing during 1976.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1									70	74	65	70	59	62
2									68	72	66	70	59	61
3									70	75	65	70	56	60
4									71	73	65	70	54	56
5									69	74	65	70	52	54
6									69	73	63	67	50	53
7									69	71	59	62	50	53
8									66	70	58	63	51	55
9									67	69	58	64	52	56
10									65	67	58	64	53	55
11									65	70	59	62	53	56
12									67	72	60	63	53	56
13									68	71	58	64	53	55
14									67	72	60	64	48	53
15									67	72	59	64	46	48
16									67	70	60	64	44	46
17									65	68	63	67	43	45
18									65	68	61	64	42	45
19									65	67	58	62	43	45
20									65	68	57	62	43	46
21									63	68	57	63	43	46
22									65	71	58	63	43	45
23							70	74	67	69	58	62	42	44
24							71	75	66	71	59	63	41	42
25							69	74	68	73	60	63	41	44
26							71	76	63	69	60	64	44	46
27							69	73	61	64	58	62	44	46
28							69	74	61	66	57	62	45	47
29							69	74	63	68	57	63	45	47
30							69	72	65	68	58	62	44	46
31							68	74	65	70			43	45

Appendix Table 8. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Coal Banks Landing during 1977.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1	39	43	57	61	63	69	67	74	70	76	60	64	52	53
2	39	42	55	62	64	68	70	74	71	77	58	63	50	55
3	37	40	58	63	63	68	66	73	72	74	61	65	51	53
4	40	45	55	59	65	72	66	70	69	71	61	67	50	51
5	43	49	52	57	67	74	65	72	65	71	65	68	48	51
6	45	52	53	56	68	76	67	71	67	72	64	69	47	51
7	47	53	52	59	72	78	65	69	69	74	64	69	49	51
8	49	55	56	61	72	76	64	71	69	74	61	64	49	51
9	52	56	57	64	70	75	65	72	68	73	59	64	46	50
10	52	56	61	65	69	72	68	70	64	71	60	67	44	48
11	51	55	59	62	65	68	65	71	65	72	61	65	44	48
12	51	56	58	65	65	66	67	73	68	72	61	65	46	50
13	51	57	59	66	63	68	69	71	69	70	60	65	49	51
14	51	54	61	66	65	70	66	73	64	69	61	66	48	50
15	50	56	56	62	67	72	69	75	63	67	60	64	46	50
16	52	58	55	58	67	69	70	77	65	71	58	60	48	51
17	51	55	53	56	65	71	72	76	67	72	57	58	49	52
18	49	55	51	54	67	74	71	74	66	73	55	61	48	52
19	50	53	53	54	69	75	70	75	68	72	58	61	49	52
20	50	53	52	57	67	71	69	74	67	71	59	61	49	51
21	49	53	54	60	68	73	68	75	66	72	58	60	48	51
22	49	56	55	62	69	75	73	79	66	70	56	61	48	51
23	52	58	58	63	70	76	75	80	65	70	56	59	48	51
24	53	60	59	63	71	77	74	77	67	70	55	57	48	51
25	55	61	59	61	71	77	69	73	64	68	53	58	49	50
26	56	61	58	65	71	77	69	74	62	66	55	58	47	49
27	56	62	61	64	71	75	72	78	62	65	53	57	45	50
28	57	63	58	62	69	73	73	79	61	64	54	55	47	50
29	58	64	55	61	67	70	71	77	60	63	53	54	49	51
30	58	64	56	64	65	73	68	70	58	60	53	54	47	50
31			59	67			68	74	57	64			46	48

Appendix Table 9. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Coal Banks Landing during 1978.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1			52	55	51	54	68	70			65	68	54	57
2			53	56	53	57	68	70			65	69	53	55
3			51	53	56	60	67	68			66	70	52	54
4			49	51	59	62	65	67			66	69	51	53
5			48	50	62	64	63	65			67	69	50	53
6			48	49	63	65	62	63			67	70	50	53
7			47	48	61	63	60	65			67	69	50	53
8			46	50	62	63	62	65			64	67	51	55
9			49	50	61	63	62	66			62	66	51	55
10			50	52	60	62	64	66			63	65	52	55
11			52	53	58	60	65	67			59	63	52	53
12			52	52	58	59	65	68			54	59	50	52
13	45	46	51	53	58	61	66	69			54	54	47	50
14	44	46	53	55	60	62	68	69			54	57	47	51
15	45	46	55	57	62	63	69	71			55	58	48	52
16	44	47	55	57	61	63	71	72			54	56	49	51
17	43	46	53	56	60	63	66	71			53	56	50	51
18	42	44	51	53	61	63	65	67			51	55	49	52
19	43	46	50	54	59	62	63	65	62	63	50	52	50	53
20	43	46	52	55	59	62	64	66	60	65	50	54	50	52
21	45	46	54	58	62	65	65	69	62	67	50	55	49	52
22	44	47	56	58	65	67	67	71	64	67	52	55	47	49
23	44	46	56	58	65	68	68	73	62	66	53	57	48	50
24	44	49	53	56	67	70	69	71	63	67	55	59	46	49
25	47	51	52	54	65	68			65	69	57	61	45	47
26	49	52	51	54	64	66			65	68	58	62	43	46
27	49	51	52	55	65	67			64	67	58	61	44	45
28	50	53	54	56	65	68			64	67	57	59	44	47
29	52	53	55	56	67	69			65	69	56	59	45	46
30	51	54	54	56	68	70			65	69	56	58	43	45
31			52	55					66	69			42	44

Appendix Table 10. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Coal Banks Landing during 1979.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1	36	38	49	51	54	56	66	69	70	74	64	69	55	58
2	37	40	47	52	56	59	65	69	70	74	65	69	54	56
3	38	40	47	51	58	61	64	70	70	74	65	71	51	56
4	37	39	47	48	60	62	67	68	70	74	65	68	52	56
5	35	37	47	49	58	60	65	71	70	75	63	67	54	57
6	35	40	47	49	58	59	68	74	70	75	63	68	53	57
7	41	43	47	48	55	57	69	74	70	74	64	69	55	58
8	41	45	46	47	54	57	71	74	70	74	64	69	53	55
9	44	47	45	48	56	59	69	74	68	73	65	68	50	53
10	42	45	45	50	58	60	70	74	68	73	62	65	51	57
11	41	42	50	51	59	63	70	73	68	71	61	64	54	58
12	40	41	49	52	61	67	68	71	66	69	60	63	55	58
13	41	43	50	54	64	67	67	71	66	69	60	65	53	56
14	41	44	51	56	63	67	67	70	63	67	60	64	53	56
15	43	47	54	59	62	65	66	71	65	71	60	65	55	56
16	45	48	56	58	62	65	67	72	67	72	61	65	53	56
17	47	51	54	57	62	67	67	74	67	72	61	65	53	55
18	46	50	55	56	64	67	70	76	68	72	61	65	50	52
19	45	48	54	57	63	65	72	76	68	72	62	65	49	51
20	45	47	54	56	61	64	72	77	68	71	61	65	47	49
21	45	47	55	58	62	64	73	78	68	70	61	64	45	47
22	44	46	56	58	62	64	73	76	67	70	60	64	44	46
23	42	44	57	59	63	66	70	74	67	72	60	64	46	49
24	41	43	59	60	64	68	69	73	67	71	60	64	46	49
25	42	46	59	62	64	69	65	69	65	67	59	63	46	49
26	45	48	61	63	66	72	63	67	65	70	61	62	47	49
27	45	49	61	63	69	72	66	72	66	71	60	63	46	48
28	48	52	58	61	68	74	68	72	65	69	59	61	46	47
29	50	53	55	58	70	74	68	71	65	70	57	61	46	48
30	50	52	55	56	69	72	68	73	66	71	58	59	44	46
31			54	56			69	74	66	69			43	44

Appendix Table 11. Daily maximum and minmum water temperatures (degrees F) for the Missouri River near Robinson Bridge during 1976.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1					61	63			70	72	67	69	58	60
2					62	63			69	70	66	68	59	61
3					61	64			69	73	65	68	59	60
4					62	63			71	72	65	68	55	56
5					61	63			69	71	66	69	51	52
6					62	64			69	71	67		51	53
7					61	62			70	71			50	53
8					61	63			69	71			51	54
9					62	64			68	70			52	55
10					63	66			67	68			53	55
11					63	65			66	69			54	56
12					63	66			67	70			53	55
13					63	64			69	71			52	54
14					61	62			68	70			49	51
15					59	62			67	71		64	46	48
16					60	62			68	70	62	65	44	45
17									67	69	63	66	42	44
18									67	69	62	65	42	43
19									66	68	60	62	40	42
20							71	73	67	68	58	61	42	44
21							71	74	65	68	58	61	42	44
22							71	74	67	71	59	61	43	44
23							71	75	69	70	58	60	42	43
24			60	61	58	61	72	74	68	71	59	60	41	42
25			60	61	58	60	72	76	69	71	57	60	40	41
26			58	60	58	60	73	76	68	69	57	59	38	42
27			58	61	57	61	73	74	62	64	57	59		
28			60	62	60	63	70	72	61	64	56	59		
29			60	62	62	66	70	73	62	66	57	60		
30			59	62	64	67	70	71	65	68	58	61		
31			61	63			68	71	66	69				

Appendix Table 12. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Robinson Bridge during 1977.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1			61	64	63	70	65	75	69	75	60	64	51	53
2			59	62	66		64	72	70	78	60	65	51	54
3			60	62	65	70	63	74	71	75	61	66	51	52
4			58	60		72	66	71	65	70	62	68	48	51
5			54	57	67		66	72	65	71	65	68	47	49
6			54	57			67	72	66	70	65	70	47	49
7			56	60			64	70	66	69	66	71	46	49
8			60	62			65	70	67	71	62	66	47	51
9			62	66			65	72	64	68	61	66	46	49
10			65	67			66	67	63	69	61	66	44	46
11			65	68			62	68	64	69	61	66	43	46
12			63	67			64	71	66	71	61	66	43	47
13		57	64	68			62	69	65	68	60	66	46	48
14	55	57	66	68			64	71	64	66	62	66	48	51
15	53	57	60	65			67	73	63	65	60	62	47	50
16	54	58	57	60			69	76	62	66	60	63	47	50
17	54	55	55	58			72	73	63	69	57	59	47	49
18	52	55	52	55			71	77	66	72	56	60	47	50
19	52	54	52	55	68	73	70	76	68	71	57	60	48	51
20	51	53	52	56	67	69	69	72	68	72	58	61	50	52
21	50	53	55	59	67	70	68	73	68	72	56	60	49	51
22	52	57	58	62	68	73	71	77	65	68	56	59	48	51
23	54	59	61	63	70	75	73	78	65	68	56	60	48	50
24	55	60	62	66	71	76	73	78	66	69	55	58	48	50
25	57	62	60	64	72	77	68	71	66	68	54	58	49	50
26	58	63	60	64	72	77	67	73	62	65	54	58	48	50
27	60	63	61	64	72	76	69	75	62	65	53	57	46	48
28	59	63	59	62	70	74	70	77	60	66	54	57	46	48
29	60	64	58	62	69	71	72	76	63	65	53	54	47	48
30	62	66	58	64	65	73	66	69	58	61	53	54	48	49
31			60	66			66	72	58	62			45	47

Appendix Table 13. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Robinson Bridge during 1978.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1			53	55	55	58	70	73	72	74	67	70	58	59
2			54	59	56	60	71	73	70	72	67	70	55	57
3			57	58	58	63	69	73	67	71	68	70	53	55
4			55	57	61	65	66	71	68	73	68	71	53	54
5			53	55	62	67	63	66	70	72	69	71	50	53
6			51	53	65	68	63	66	70	75	69	71	51	53
7			50	51	65	68	64	68	72	76	70	72	51	53
8			50	53	66	69	66	68	72	75	68	71	52	54
9			51	54	66	69	63	66	73	77	65	68	53	55
10			53	56	64	67	64	69	74	77	65	66	53	55
11			53	55	62	64	67	70	73	76	62	65	53	55
12			53	56	60	63	67	69	72	75	56	62	52	54
13			54	57	61	64	66	70	71	74	55	56	50	52
14			56	58	62	65	68	72	68	71	54	57	48	50
15			57	61	63	66	69	74	68	71	56	59	49	51
16			58	60	63	66	71	74	68	71	56	58	50	51
17			57	59	63	66	71	73	64	68	54	56	50	51
18			54	57	64	67	67	71	62	65	54	56	50	52
19			53	56	64	67	66	68	62	65	52	53	50	52
20			55	58	61	64	65	68	63	66	50	53	50	52
21			57	60	63	67	66	70	64	68	52	55	51	52
22			59	62	67	70	67	71	66	68	54	57	49	51
23			59	61	68	71	69	74	66	68	56	59	48	50
24			58	61	70	71	72	75	66	69	57	59	48	49
25			57	58	66	70	73	77	66	70	58	61	47	48
26	52	54	56	59	65	68	74	77	68	71	59	61	46	48
27	53	54	56	60	66	70	73	76	68	70	59	62	45	46
28	53	54	57	61	67	72	73	76	66	69	60	61	44	46
29	53	54	58	61	70	72	72	75	66	70	58	60	45	46
30	53	55	58	60	70	73	72	76	68	70	57	59	43	45
31			56	58			72	75	68	70			43	44

Appendix Table 14. Daily maximum and minimum water temperatures (degrees F) for the Missouri River near Robinson Bridge during 1979.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1			51	53	57	60	70	73	73	76	66	69	56	58
2			50	53	58	62	69	72	73	76	68	70	54	57
3			51	52	60	63	68	71	73	76	68	72	54	56
4			49	50	62	65	70	71	72	76	66	69	53	56
5			49	50	63	65	69	72	72	75	65	68	55	57
6			49	51	61	63	69	72	73	77	65	68	55	57
7			48	50	59	60	71	75	74	76	66	69	56	58
8			48	50	57	60	72	76	74	75	67	69	53	57
9			48	50	59	62	73	76	72	76	67	70	52	54
10			48	53	60	65	74	76	72	74	64	66	53	55
11			52	54	63	66	73	75	71	73	63	64	54	56
12			52	55	64	68	72	74	70	71	61	62	56	57
13			54	57	66	70	71	73	68	69	60	63	55	57
14			55	59	67	68	69	71	65	67	60	63	55	57
15			56	61	66	67	68	71	64	69	61	65	56	57
16			60	62	65	67	68	72	68	72	62	66		
17			59	60	64	66	70	74	69	73	64	67		
18			58	60	65	67	71	76	71	73	63	66		
19			58	60	65	69	73	78	71	73	63	66		
20			57	60	66	67	74	78	71	73	62	65		
21		50	58	61	64	67	75	80	70	72	62	65		
22	47	49	59	62	64	67	76	79	68	71	62	65		
23	44	45	60	63	65	69	74	77	69	72	61	64		
24	44	45	61	64	66	70	74	76	70	72	61	64		
25	44	47	62	65	68	70	70	73	67	71	61	64		
26	46	49	63	67	68	72	68	70	66	69	62	64		
27	47	51	65	66	70	73	67	72	67	70	62	64		
28	50	52	63	64	71	75	70	73	67	70	61	63		
29	50	53	60	61	72	76	70	72	69	72	59	62		
30	51	54	58	60	73	76	70	73	70	72	57	60		
31			58	59			71	75	66	70				

Appendix Table 15. Daily maximum and minimum water temperatures (degrees F) for the Marias River near the mouth during 1977.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1	37	43	55	63	64	71	68	76	66	80	60	67	52	54
2	36	41	54	63	62	72	69	74	70	81	59	67	49	56
3	36	40	57	64	66	77	63	73	71	76	62	70	51	54
4	39	46	52	59	67	79	64	68	68	70	63	72	47	52
5	42	51	46	56	70	83	63	74	63	74	67	74	44	49
6	45	55	49	54	74	82	66	71	65	75	65	75	44	51
7	48	58	50	64	72	78	60	71	67	77	65	73	47	50
8	51	61	58	66	69	79	63	75	67	78	63	70	46	51
9	53	60	59	71	66	71	66	75	64	72	57	67	47	49
10	52	58	63	71	63	65	65	70	60	73	61	70	41	47
11	49	58	59	67	61	64	61	74	63	75	61	68	40	48
12	49	59	58	71	60	69	67	76	67	74	59	68	43	53
13	50	60	61	73	64	73	66	70	68	71	59	68	49	54
14	51	56	64	70	65	72	64	77	63	68	61	69	48	53
15	48	59	54	64	65	69	68	79	61	69	61	66	45	52
16	52	60	51	56	64	73	70	81	62	74	59	62	48	54
17	48	56	49	55	66	78	72	75	65	77	56	59	47	52
18	47	57	47	51	68	77	70	74	69	80	54	63	46	53
19	47	53	49	52	65	75	68	77	70	78	56	63	48	52
20	47	53	50	60	67	75	66	74	70	76	59	64	48	52
21	47	53	54	64	67	75	67	79	68	78	57	63	47	51
22	48	59	57	67	67	77	72	83	68	72	55	62	45	51
23	51	62	61	68	68	78	75	84	65	73	53	61	46	52
24	53	65	62	67	70	79	71	79	67	72	54	57	47	50
25	56	66	58	69	71	80	68	70	63	69	51	60	48	50
26	56	65	60	66	69	80	67	77	62	68	53	60	47	50
27	54	64	55	61	70	76	70	79	61	67	51	57	52	47
28	54	66	51	62	67	72	70	82	59	67	54	56	44	49
29	56	67	54	67	65	72	73	77	61	65	53	56	47	49
30	59	67	60	72	65	75	64	70	57	60	54	56	45	49
31			66	75			62	75	57	66			42	45

Appendix Table 16. Daily maximum and minimum water temperatures (degrees F) for the Marias River near the mouth during 1978.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1	40	46	52	60	61	69	67	72	63	70	61	68	52	59
2	40	47	52	57	62	70	66	72	62	73	62	69	51	58
3	40	47	51	57	61	71	66	72	63	72	63	70	50	57
4	41	47	50	55	61	72	66	72	63	72	64	72	49	56
5	42	56	48	54	62	71	62	68	66	74	60	68	48	55
6	41	47	47	53	62	71	62	71	66	74	58	65	48	56
7	40	47	46	54	62	70	62	73	67	76	56	63	48	56
8	43	49	49	56	61	70	61	69	68	76	56	63	48	55
9	44	50	53	61	62	69	64	71	68	77	58	65	47	55
10	44	51	54	62	60	69	64	74	69	78	56	62	47	54
11	43	50	54	64	61	69	64	74	68	77	54	60	46	56
12	42	50	54	64	59	69	64	74	63	74	52	58	47	55
13	42	49	56	66	60	70	66	74	62	69	50	53	48	56
14	41	48	55	66	59	69	68	77	62	69	51	58	49	56
15	41	48	54	66	57	68	66	72	61	68	50	57	48	55
16	40	47	56	66	60	67	64	70	58	64	50	55	46	53
17	41	47	53	62	61	68	63	69	55	62	50	54	47	55
18	42	47	55	63	62	69	62	68	53	61	49	54	49	55
19	44	48	56	63	63	70	62	67	59	65	48	51	47	54
20	47	53	57	66	63	71	64	69	57	65	47	54	48	55
21	48	54	56	67	62	68	66	74	58	66	53	59	46	54
22	47	54	56	65	63	66	69	76	60	67	53	59	44	52
23	47	54	54	61	64	66	70	77	62	68	53	59	42	51
24	46	53	52	59	63	66	71	78	63	69	55	61	41	49
25	47	54	53	61	63	66	71	77	62	71	57	64	42	47
26	48	55	54	62	65	72	70	76	63	72	55	62	40	46
27	48	55	55	62	64	72	70	76	63	68	54	62		
28	51	56	54	61	66	75	69	76	62	67	54	62		
29	51	56	56	62	68	79	69	76	61	68	54	62		
30	52	59	60	66	66	72	67	73	61	66	53	60		
31			61	68			65	71	61	68				

Appendix Table 17. Daily maximum and minimum water temperatures (degrees F) for the Marias River near the mouth during 1979.

Day	April Min.	April Max	May Min.	May Max.	June Min.	June Max.	July Min.	July Max.	Aug. Min.	Aug. Max.	Sept. Min.	Sept. Max.	Oct. Min.	Oct. Max.
1					51	58	59	63	65	73	64	68	54	56
2					54	61	58	63	65	73	65	69	54	55
3					57	64	58	67	65	72	65	71	51	55
4					59	63	63	65	65	71	66	69	51	55
5					57	59	61	68	66	74	62	68	53	56
6					54	57	63	71	65	73	62	68	53	57
7					51	54	65	73	65	72	64	70	55	57
8					49	57	66	70	65	72	65	70	54	57
9					53	61	63	70	63	70	65	68	50	53
10					57	62	65	72	63	70	62	65	50	55
11					58	64	64	70	64	68	60	62	53	56
12					60	67	62	68	63	68	59	62	55	57
13					62	67	60	68	62	67	60	64	54	57
14				54	61	66	60	66	60	67	59	64	53	56
15			51	57	58	64	60	67	62	69	59	65	54	56
16			53	55	58	64	62	70	63	70	61	65	52	55
17			49	54	59	63	63	72	64	71	61	65	52	54
18			50	54	61	65	65	74	65	70	61	65	48	53
19			50	55	61	63	66	74	65	69	61	65	49	50
20			49	54	59	63	67	75	64	68	60	65	46	49
21			51	58	59	64	68	75	65	67	60	63	44	46
22			52	59	60	64	68	70	61	66	59	63	42	45
23			54	62	60	66	64	71	62	69	59	63	44	47
24			57	60	61	67	64	66	65	66	59	63	45	47
25			56	63	62	68	61	62	62	65	58	62	46	48
26			57	66	63	70	57	63	61	68	60	61		
27			61	64	65	69	59	69	63	68	58	61		
28			56	59	63	70	63	68	64	70	57	60		
29			52	57	63	70	64	70	62	69	56	59		
30			52	58	65	69	64	72	64	71	57	58		
31			52	58			65	73	66	68				

Appendix Table 18. Numbers of aquatic macroinvertebrates collected (per sample period) at the Morony Dam site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Mayfly								
Tricorythodes		1			2	15	6	1
Ephemerella					2			
Rhithrogena						1		
Stenonema	18	5		3	2	4		
Baetis	2	5	19	376	296	671	6	18
Stonefly								
Acroneuria					1			
Truefly								
Chironomidae	121	215	24	168	936	436	2504	2038
Diamesa					4			
Monodiamesa					<1			
Potthastia							<1	
Chironomus							3	4
Dicrotendipes					<1	1	35	39
Microtendipes					1			
Paracladopelma						1		
Phaenopsectra					2	28	21	15
Polypedilum					<1	4	35	
Micropsectra							<1	
Rheotanytarsus					1	1	<1	3
Tanytarsus					<1			1
Cardiocladius					3			
Cricotopus					42	25	1	29
Eukiefferiella						4		
Orthocladius					45	36	4	9
Hexatoma		1						
Simulium							2	
Empididae					1	5	2	4
Muscidae							4	
Caddisfly								
Hydroptila	10			12	31	20	46	9
Leucotrichia					6	2		
Hydropsyche	315	32	15	39	414	277	30	44
Cheumatopsyche	9	1		2	10	5	12	
Psychomyia						1		
Oecetis	14	49	2	9	17	1		4
Brachycentrus					12	6		1
Amiocentrus					3	2	6	

Appendix Table 18 continued. Numbers of aquatic macroinvertebrates collected (per sample period) at the Morony Dam site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Odonata								
Ophiogomphus					1			
Heteroptera								
Sigara								64
Trichocorixa								4
Coleoptera								
Hydrophilus							2	
Optioservus	1							
Lepidoptera								
Parargyractis	5		2	1	26	10	2	5
Oligochaeta		19		1	6	16		148
Nematomorpha				14		2		
Amphipoda								
Hyallela								1
Decapoda								
Orconectes	1					2	6	4
Total	496	328	62	625	1764	1511	2692	2346

* Chironomidae subordinal taxa expressed as a percentage of the family's total count.

Appendix Table 19. Numbers of aquatic macroinvertebrates collected (per sample period) at the Fort Benton site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Mayfly								
Paraleptophlebia							1	
Tricorythodes	2	4			1	20	20	24
Ephemerella	16		37	43	111	2		
Rhithrogena			4	20	10			
Stenonema	3	21	2	4	9	2	2	31
Heptagenia			2	2	10			
Baetis	1	11	230	4468	1767	492	6	109
Stonefly								
Acroneuria				2				
Isogenus			1		3			
Isoperla		1	12	31	22	2		
Truefly								
Chironomidae	869	754	1133	1671	787	6892	392	695
Thienemannimyia					<1	1	11	5
Monodiamesa					2	<1	4	
Chironomus						<1	1	
Cryptochironomus							7	<1
Demicryptochironomus					<1	<1		
Dicrotendipes							1	
Microtendipes					91		34	61
* *Phaenopsectra*					4	5	15	3
Polypedilum					2	90	26	4
Rheotanytarsus						1		<1
Tanytarsus							1	
Cricotopus					<1	<1		25
Eukiefferiella						1		<1
Orthocladius					<1			2
Tipula					2			1
Simulium		3	3	2		6		
Empididae	2	7			2	2		7
Caddisfly								
Hydroptila	46	212	277	396	363	192	1574	170
Hydropsyche	48	103	291	140	117	1392	30	1018
Cheumatopsyche	4	22	29	15	6	82	36	644
Oecetis		5	15	6	5		22	157
Brachycentrus		2	2	1	4	38	10	40
Odonata								
Ophiogomphus								1

Appendix Table 19 continued. Numbers of aquatic macroinvertebrates collected (per sample period) at the Fort Benton site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Heteroptera								
Trichocorixa		2			1			
Hesperocorixa		1			8			
Sigara	18			1	128		738	1
Coleoptera								
Hydroporus		1						
Dytiscus	1							
Pelonomus					1			
Dubiraphia		1			1			
Ordobrevia								1
Optioservus				1		6		
Lepidoptera								
Parargyractis	1		2	1	3			
Nematomorpha			2	2	3	2		
Oligochaeta	224	14	22	94	92	14	282	53
Pulmonata								
Ferrissia	1		1	1	3		16	
Decapoda								
Orconectes							2	
Total	1237	1189	2064	6901	3367	9200	3128	2956

* Chironomidae subordinal taxa expressed as a percentage of the family's total count.

Appendix Table 20. Numbers of aquatic macroinvertebrates collected (per sample period) at the Coal Banks Landing site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Mayfly								
Baetisca								1
Leptophlebia							2	
Traverella							2	
Tricorythodes						95	30	19
Ephemerella				38	54	13		
Rhithrogena			3	432	31			1
Stenonema	3		1	6		16	14	315
Heptagenia	2	1	1		13	58	14	3
Baetis	2	1	8	660	280	180	152	69
Stonefly								
Isogenus				20				
Isoperla				21	46	1		
Brachyptera	1							
Truefly								
Chironomidae	91	112	44	2311	44	1192	1862	363
Thienemannimyia						1	9	1
Diamesa					6			
Monodiamesa					40	<1		
Chironomus						50	4	
Cryptochironomus						1	4	<1
Dicrotendipes								1
Microtendipes					20		3	92
* *Phaenopsectra*						3	4	
Polypdilum					15	40	72	1
Rheotanytarsus						4	1	<1
Tanytarsus							1	
Cricotopus					4			4
Orthocladius					15	<1	<1	<1
Simulium		1						2
Empididae							2	1
Caddisfly								
Hydroptila				6		2	24	5
Hydropsyche	9	7	3	20	3	17	60	128
Cheumatopsyche	5	3	1	19		7	72	78
Oecetis		1		5		6	10	72
Helicopsyche								1
Brachycentrus						37	10	8
Odonata								
Ophiogomphus						1		

Appendix Table 20 continued. Numbers of aquatic macroinvertebrates collected (per sampling period) at the Coal Banks Landing site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Heteroptera								
Trichocorixa							16	
Sigara	6		5		4	2	330	30
Coleoptera								
Gyrinus					2			
Hydroporus	1	1						
Curculionidae					1			
Ordobrevia								2
Lepidoptera								
Synclita					2			
Oligochaeta	28	34			85	63	172	43
Plumonata								
Physa								5
Total	148	161	66	3538	565	1692	2778	1148

* Chironomidae subordinal taxa expressed as a percentage of the family's total count.

Appendix Table 21. Numbers of aquatic macroinvertebrates collected (per sample period) at the Judith Landing site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Mayfly								
Leptophlebia						1		
Traverella							160	1
Ephoron						2	6	
Tricorythodes					1	101	94	54
Ephemerella	38	6	N	13	162	28		
Rhithrogena	33	107		156	209	215	41	1
Stenonema	18	3	O	4	26	19	23	47
Heptagenia	154	49		8	92	239	6	30
Baetis	2	7	T	79	226	96	84	8
Stonefly								
Capnia		32	S	1				
Acroneuria	1	1		1	4			
Isogenus	1	1	A	73	17			
Isoperla				9	34	39	5	
			M					
Truefly								
Chironomidae	91	57	P	644	65	92	24	88
Thienemannimyia						9	50	15
Monodiamesa			L		65	23		
Chironomus						15	15	27
Cryptochironomus			E		2	2		6
Demicryptochironomus						2		
Microtendipes			D		4	3		44
Phaenopsectra					2		20	1
* *Polypedilum*					10	42	10	
Cladotanytarsus							5	
Rheotanytarsus						3		2
Tanytarsus					8			5
Cricotopus					8			
Eukiefferiella						1		
Orthocladius					2			
Simulium	1						1	
Caddisfly								
Hydropsyche	40	7			26	47	48	2
Cheumatopsyche	155	8		6	2	1	36	7
Oecetis	2	1		1	2		9	2
Brachycentrus	91	1		6	1	266	384	5
Heteroptera								
Trichocorixa	86				4	1		
Hesperocorixa								1
Sigara	5	9		2	120	12	49	15

Appendix Table 21 continued. Numbers of aquatic macroinvertebrates collected (per sampling period) at the Judith Landing site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Coleoptera								
Carabidae						1		
Hydrovatus				2				
Curculionidae						1		
Dubiraphia						2		1
Ordobrevia						1	2	
Stenelmis							2	8
Oligochaeta	2					157	17	88
Total	724	289		1005	1276	1322	995	358

* Chironomidae subordinal taxa expressed as a percentage of the family's total count.

Appendix Table 22. Numbers of aquatic macroinvertebrates collected (per sample period) at the Robinson Bridge site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Mayfly								
Leptophlebia	1					1	8	4
Traverella						22		1
Ephoron						3		
Ametropus	2				1			
Tricorythodes				1	3	26	17	16
Brachycercus						6	1	
Ephemerella				21	58	1		
Rhithrogena	5			30	8	1		
Stenonema	5	N	N	15	44	33	9	132
Heptagenia	18			192	248	275	40	39
Baetis		O	O	28	32	29	30	7
Stonefly		T	T					
Brachyptera	1			8				
Capnia				24				
Acroneuria	1	S	S	1	8	1		
Isogenus				31				
Isoperla		A	A	36	62	8		
Truefly		M	M					
Chironomidae	12			825	10	49	12	7
Thienemannimyia		P	P			4	45	25
Monodiamesa					85	12		
Cryptochironomus		L	L			4		
* *Polypedilum*					15	40	55	
Stenochironomus		E	E			4		25
Micropsectra						4		
Rheotanytarsus		D	D			20		25
Eukiefferiella						12		25
Simulium							1	1
Empididae					1			
Caddisfly								
Hydropsyche					27	22		1
Cheumatopsyche	18			55		1		8
Oecetis								2
Brachycentrus				5		28		16
Odonata								
Gomphus						1		
Ophiogomphus				1	3		1	
Heteroptera								
Trichocorixa	1			5	6			
Sigara					26	6	149	22

Appendix Table 22 continued. Numbers of aquatic macroinvertebrates collected (per sample period) at the Robinson Bridge site, late October, 1976, through mid-September, 1977.

	Sampling Period							
	late Oct.	mid Dec.	late Jan.	mid Mar.	early May	mid June	early Aug.	mid Sept.
Coleoptera								
Hydrophilus					2		2	
Hydrovatus	1			25				
Dubiraphia						1		1
Ordobrevia						2	1	2
Stenelmis						1		1
Nematomorpha							1	
Oligochaeta	10			81	19	22	65	18
Total	77			1384	558	558	336	288

* Chironomidae subordinal taxa expressed as a percentage of the family's total count.

Appendix Table 23. Numbers of aquatic macroinvertebrates collected (per sample date) in the lower Marias and Judith rivers, 1977 and 1978.

	Marias River				Judith River		
	5/05/77	8/05/77	10/19/77	5/31/78	8/05/77	11/08/77	4/29/78
Mayfly							
Baetisca			1	5			
Leptophlebia					1		
Traverella		38	1		104		
Ephemera				2			
Hexagenia	collected in larval fish samples						
Ephoron		15					
Tricorythodes		1	1	27	168	14	
Ephemerella	39			10		22	28
Isonychia		1					
Rhithrogena	26		45		8	55	2
Stenonema	3	7	28	59		51	
Heptagenia					9	11	1
Baetis	8	3		2	109	3	2
Pseudocloeon	collected in larval fish samples						
Stonefly							
Brachyptera						3	
Acroneuria		5		1			
Claassenia	1	1	3				
Isogenus	14	5	2		12	44	
Isoperla	8						1
Caddisfly							
Hydroptila	1	2	4		9	2	
Hydropsyche	5	15	53	26	81	60	7
Cheumatopsyche		33	96	40	163	305	1
Oecetis		1	18	3	13	1	
Helicopsyche		1	1				
Brachycentrus		1	1		285	13	1

Appendix Table 23 continued. Numbers of aquatic macroinvertebrates collected (per sample date) in the lower Marias and Judith rivers, 1977 and 1978.

	Marias River				Judith River		
	5/05/77	8/05/77	10/19/77	5/31/78	8/05/77	11/08/77	4/29/78
Truefly							
Hexatoma					2	1	
Atherix					13	3	2
Simulium				12	9	2	1
Empididae			1	2	2		
Chironomidae	3	9	38	2	65	23	1
Thienemannimyia					14		
Monodiamesa	1						
Potthastia					1		
Polypedilum		7			9		
* *Microtendipes*	2	2	38			3	
Rheotanytarsus					24		
Cricotopus					5		
Eukiefferiella					26	1	
Orthocladius						20	
Odonata							
Ophiogomphus	1	20	10	8	11		
Heteroptera							
Trichocorixa		1					
Sigara	1	9					
Coleoptera							
Hydrophilidae							1
Ordobrevia			1				1
Microcylleopus				1	6	1	
Pulmonata							
Physa		1				3	

Appendix Table 23 continued. Numbers of aquatic macroinvertebrates collected (per sample date) in the Lower Marias and Judith rivers, 1977 and 1978.

	Marias River				Judith River		
	5/05/77	8/05/77	10/19/77	5/31/77	8/05/77	11/08/77	4/29/78
Oligochaeta		8			2	2	
Total	110	177	304	200	1072	619	49

* Chironomidae subordinal taxa expressed as a percentage of the family's total count.

Appendix Table 24. Numbers of larval fish collected (per sample) in the middle Missouri and lower Marias rivers, late May through mid-August, 1978.

Sample Site	Date	No. Larvae per Taxon[1/]	Total No. of Larvae	No. Larvae per 100 m^3
Carter Ferry	June 6	2 ctm	2	4.6
	June 6	23 ctm	23	52.5
	June 30	300 ctm, 37 icy	337	77.5
	July 12	7 ctm	7	1.5
	July 19	16 ctm, 5 icy	21	6.0
Fort Benton	June 5	5 ctm	5	26.3
	June 5	21 ctm	21	55.2
	June 6	35 ctm	35	92.0
	June 12	21 ctm	21	27.6
	June 13	2 ctm	2	1.4
	June 30	30 ctm, 7 icy	37	9.7
	July 12	176 ctm, 8 icy	184	37.1
Coal Banks	June 13	50 ctm, 9 icy, 1 sgr	60	74.3
	June 30	2528 ctm, 190 icy	2718	587.0
	July 13	1 pfi, 1177 ctm, 49 icy	1227	259.0
Little Sandy	June 14	3 ctm, 2 icy	5	5.4
	June 14	3 ctm, 2 icy	5	3.9
	June 29	39 ctm, 5 icy	44	20.2
	June 29	48 ctm	48	11.0
	July 12	1 pfi, 7 ctm, 6 icy	14	3.2
	July 12	35 ctm	35	7.9
	July 21	2 ctm	2	0.5
Judith Landing	June 15	1 gld, 6 ctm, 5 icy	12	5.5
	June 28	6 ctm, 2 icy	8	5.0
	July 11	17 ctm, 2 icy	19	4.0
	Aug 19	17 ctm, 4 icy	21	5.9

Appendix Table 24 continued. Numbers of larval fish collected (per sample) in the middle Missouri and lower Marias rivers, late May through mid-August, 1978.

Sample Site	Date	No. Larvae per Taxon[1/]	Total No. of Larvae	No. Larvae per 100 m^3
Stafford Ferry	May 25	3 ctm	3	6.2
	May 25	1 ctm	1	3.4
	June 15	1 gld, 54 ctm, 1 sgr	56	20.6
	June 28	6 ctm, 4 icy	10	5.3
	June 28	5 ctm, 5 icy	10	5.3
	June 28	8 ctm, 4 icy	12	6.3
	July 10	240 ctm, 54 icy	294	91.4
	July 23	74 ctm, 291 icy	365	80.7
Cow Island	June 15	27 ctm, 17 icy	44	16.7
	June 27	6 ctm, 20 icy	26	12.6
	June 27	17 ctm, 18 icy	35	16.9
	June 27	2 gld, 25 ctm, 37 icy	64	31.0
	July 11	72 ctm, 16 icy	88	22.6
	July 24	7 ctm	7	1.9
	Aug 20	1 sto	1	0.3
Robinson Bridge	May 26	-	0	0.0
	June 16	21 ctm, 51 icy	72	36.2
	June 28	16 ctm, 8 icy	24	14.7
	July 11	2 ctm, 2 icy	4	0.6
Marias River	June 1	10 ctm	10	28.9
	June 1	19 ctm, 1 scu	20	57.8
	June 1	75 ctm, 4 sgr	79	228.3
	June 2	121 ctm, 2 sgr	123	355.5
	June 2	61 ctm, 5 sgr	66	190.7
	June 2	45 ctm	45	130.1
	June 19	2 sns, 35 ctm, 21 icy, 1 cat	59	14.8
	July 1	132 ctm, 28 icy	160	52.2
	July 4	136 ctm, 58 icy	194	48.5

Appendix Table 24 continued. Numbers of larval fish collected (per sample) in the middle Missouri and lower Marias rivers, late May through mid-August, 1978.

Sample Site	Date	No. Larvae per Taxon[1/]	Total No. of Larvae	No. Larvae per 100 m^3
	July 13	3 gld, 62 ctm, 14 icy	79	21.5
	July 28	90 ctm, 38 icy, 3 cat	131	36.3

1/ Abbreviations: sns = shovelnose sturgeon, pfi = paddlefish, gld = goldeye, ctm = Catostominae, icy - Ictiobinae/Cyprinidae, cat = channel catfish, sto = stonecat, sgr = sauger, and scu = sculpin.

Appendix Table 25. Legal descriptions of boundaries of eleven fishery study sections on the mainstem of the middle Missouri River.

Study Section Boundary	Legal Description of Boundary
Morony Dam (upper)	NE¼, NW¼, Sec. 14, T21N, R5E
Morony Dam/Carter Ferry	NW¼, NE¼, Sec. 27, T23N, R6E
Carter Ferry/Fort Benton	NW¼, SW¼, Sec. 33, T24N, R8E
Fort Benton/Loma Ferry	SW¼, SE¼, Sec. 2, T24N, R9E
Loma Ferry/Coal Banks Landing	SE¼, SW¼, Sec. 20, T26N, R11E
Coal Banks Landing/Hole-in-the-Wall	SE¼, SW¼, Sec. 30, T26N, R13E
Hole-in-the-Wall/Judith Landing	SW¼, E½, Sec. 31, T23N, R15E
Judith Landing/Stafford Ferry	SW¼, SW¼, Sec. 23, T23N, R17E
Stafford Ferry/Cow Island	SE¼, NE¼, Sec. 9, T23N, R20E
Cow Island/Robinson Bridge	SE¼, SW¼, Sec. 21, T23N, R22E
Robinson Bridge/Turkey Joe	NE¼, NW¼, Sec. 1, T21N, R24E
Turkey Joe (lower)	NE¼, SE¼, Sec. 15, T21N, R26E

Appendix Table 26. Species composition, number, and size of fish sampled by electrofishing in the Morony Dam study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Goldeye	75	31.7	28.4-36.1	0.26	0.19-0.43
Mountain whitefish	32	30.8	9.7-43.4	0.41	0.02-1.05
Rainbow trout	18	32.7	15.7-40.9	0.36	0.15-0.64
Brown trout	16	41.0	21.6-58.4	0.73	0.11-1.95
Northern pike	1	57.9	-	1.28	-
Carp	5	55.5	50.3-62.7	2.31	1.56-3.72
Flathead chub	1	8.6	-	0.01	-
Emerald shiner	6	6.9	6.4- 7.1	0.01	-
W. silvery minnow	150	9.4	8.1-10.7	0.02	0.01-0.02
Longnose dace	9	8.3	7.6- 8.9	0.01	-
River carpsucker	2	42.0	41.9-42.2	0.93	0.86-1.00
Blue sucker	4	71.8	66.3-76.2	3.10	2.22-4.31
Smallmouth buffalo	31	55.7	46.2-69.3	2.82	1.50-6.80
Bigmouth buffalo	2	63.0	46.5-79.5	5.47	1.50-9.43
Shorthead redhorse	24	45.9	33.5-51.8	1.13	0.45-1.81
Longnose sucker	65	38.1	13.2-50.3	0.68	0.04-1.25
White sucker	8	30.8	14.5-42.2	0.41	0.04-0.88
Mountain sucker	21	15.8	8.9-21.6	0.06	0.02-0.11
Burbot	6	59.2	36.8-66.0	1.25	0.36-1.74
Sauger	664	35.6	22.6-56.1	0.38	0.09-1.50
Walleye	11	39.2	27.7-77.0	0.86	0.18-5.35
Freshwater drum	85	37.9	27.7-52.8	0.85	0.25-2.31
Mottled sculpin	15	8.6	7.9- 9.7	0.02	0.01-0.02
Total	1251				

Appendix Table 27. Species composition, number, and size of fish sampled by electrofishing in the Carter Ferry study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	2	96.9	90.7-103.1	4.65	3.40-5.90
Goldeye	175	31.8	26.7- 36.6	0.27	0.15-0.43
Mountain whitefish	7	27.2	15.7- 39.6	0.27	0.03-0.59
Rainbow trout	1	27.7	-	0.23	-
Brown trout	5	35.3	28.7- 40.9	0.52	0.25-0.75
Northern pike	1	96.5	-	7.08	-
Carp	3	50.0	49.3- 50.8	1.67	1.48-1.81
Flathead chub	1	16.8	-	0.05	-
Emerald shiner	2	7.1	6.6- 7.6	0.01	-
W. silvery minnow	6	9.4	8.9- 9.9	0.02	0.01-0.02
Longnose dace	6	6.8	5.8- 8.4	0.01	-
River carpsucker	3	42.5	38.6- 47.2	1.08	0.88-1.29
Blue sucker	11	67.1	60.2- 78.7	2.68	2.09-4.99
Smallmouth buffalo	21	57.9	49.0- 68.1	3.21	1.86-4.58
Bigmouth buffalo	1	71.4	-	5.31	-
Shorthead redhorse	61	45.2	34.0- 52.6	1.10	0.49-1.47
Longnose sucker	68	42.3	22.1- 50.3	0.93	0.11-1.53
White sucker	1	40.6	-	0.83	-
Mountain sucker	1	19.3	-	0.11	-
Burbot	4	58.0	51.8- 63.0	1.03	0.73-1.39
Yellow perch	1	11.4	-	0.02	-
Sauger	358	37.0	25.7- 48.3	0.40	0.11-0.91
Walleye	1	31.7	-	0.25	-
Freshwater drum	17	39.8	28.2- 52.6	0.98	0.29-1.97
Mottled sculpin	3	8.9	8.1- 9.4	0.01	0.01-0.02
Total	760				

Appendix Table 28. Species composition, number, and size of fish sampled by electrofishing in the Fort Benton study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	37	87.2	68.6-101.6	3.03	1.66-4.26
Goldeye	198	31.6	27.9- 39.4	0.27	0.16-0.51
Mountain whitefish	119	36.8	9.9- 49.5	0.68	0.01-1.42
Rainbow trout	4	29.6	25.9- 39.9	0.37	0.18-0.94
Brown trout	14	40.8	27.9- 50.3	0.72	0.25-1.27
Brook trout	2	24.0	23.4- 24.6	0.14	0.13-0.15
Carp	56	49.5	31.2- 61.7	1.59	0.51-3.36
Flathead chub	34	15.7	8.4- 20.3	0.05	0.01-0.11
Emerald shiner	6	7.4	-	0.01	-
W. silvery minnow	7	10.6	9.7- 13.0	0.02	0.01-0.03
Longnose dace	12	7.8	4.8- 11.7	0.01	0.01-0.02
River carpsucker	16	40.7	36.3- 44.7	0.90	0.59-1.20
Blue sucker	29	66.4	41.4- 82.6	2.66	0.90-4.54
Smallmouth buffalo	57	58.2	46.2- 69.9	3.18	1.45-5.13
Bigmouth buffalo	22	73.7	35.6- 83.3	7.59	1.20-10.43
Shorthead redhorse	327	42.6	10.9- 53.8	0.91	0.02-2.16
Longnose sucker	180	37.5	15.0- 50.3	0.66	0.07-1.64
White sucker	17	33.1	22.6- 44.2	0.50	0.15-0.96
Mountain sucker	8	13.5	8.6- 18.5	0.04	0.01-0.09
Stonecat	1	14.2	-	0.04	-
Burbot	14	57.0	39.1- 62.5	1.04	0.34-1.56
Sauger	671	33.9	18.5- 60.2	0.33	0.04-2.40
Walleye	7	58.5	32.3- 74.7	2.54	0.32-5.49
Freshwater drum	29	34.5	26.7- 42.2	0.58	0.27-0.98
Mottled sculpin	15	8.2	5.6- 10.4	0.01	0.01-0.02
Total	1882				

Appendix Table 29. Species composition, number, and size of fish sampled by electrofishing in the Loma Ferry study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	190	82.7	63.8-100.8	2.53	0.96- 4.67
Goldeye	170	31.0	27.9- 35.3	0.25	0.17- 0.38
Mountain whitefish	39	26.4	9.1- 42.4	0.26	0.01- 1.23
Brown trout	2	34.9	9.4- 60.5	1.09	0.01- 2.16
Northern pike	5	64.2	33.3- 91.4	2.45	0.28- 5.22
Carp	39	47.2	25.1- 58.4	1.42	0.22- 3.04
Flathead chub	158	13.5	7.9- 24.6	0.03	0.01- 0.15
Emerald shiner	32	7.3	5.1- 9.7	0.01	-
W. silvery minnow	3	13.0	12.7- 13.5	0.02	0.02- 0.03
Longnose dace	2	7.1	6.9- 7.4	0.01	-
River carpsucker	32	39.6	13.5- 50.8	0.85	0.01- 1.68
Blue sucker	86	66.8	55.1- 87.1	3.21	1.88- 8.16
Smallmouth buffalo	94	57.8	40.4- 72.1	3.12	0.98- 6.49
Bigmouth buffalo	23	72.2	42.4- 93.5	6.39	5.22-12.25
Shorthead redhorse	189	40.6	14.7- 50.8	0.82	0.03- 1.49
Longnose sucker	230	38.1	12.7- 52.1	0.73	0.04- 1.42
White sucker	5	32.0	25.7- 41.1	0.42	0.22- 0.72
Mountain sucker	2	15.0	12.7- 17.3	0.05	0.02- 0.08
Burbot	10	46.0	32.0- 55.1	0.50	0.17- 0.75
Yellow perch	7	14.1	10.9- 22.1	0.04	0.02- 0.11
Sauger	481	33.2	15.7- 57.9	0.33	0.02- 1.54
Walleye	17	51.7	26.2- 76.2	2.15	0.11- 5.99
Freshwater drum	55	32.4	26.4- 45.2	0.46	0.23- 1.27
Mottled sculpin	1	7.9	-	0.01	-
Total	1872				

Appendix Table 30. Species composition, number, and size of fish sampled by electrofishing in the Coal Banks Landing study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Pallid sturgeon	1	135.1	-	14.52	-
Shovelnose sturgeon	236	83.5	57.2-112.3	2.29	0.52- 5.58
Goldeye	276	31.1	26.2- 37.3	0.27	0.17- 0.43
Mountain whitefish	9	22.8	17.0- 31.5	0.13	0.05- 0.21
Northern pike	1	80.8	-	3.13	-
Carp	62	47.3	36.6- 61.7	1.40	0.60- 2.95
Flathead chub	64	16.8	9.4- 23.6	0.06	0.01- 0.13
Emerald shiner	3	7.5	6.6- 8.6	0.01	-
W. silvery minnow	9	10.8	9.7- 11.7	0.02	0.01- 0.02
River carpsucker	21	41.8	37.3- 47.2	0.94	0.72- 1.39
Blue sucker	76	70.7	60.5- 87.9	3.27	1.84- 6.58
Smallmouth buffalo	69	57.0	43.4- 80.0	3.08	1.02- 7.48
Bigmouth buffalo	12	76.3	69.6- 85.1	7.59	4.94-10.80
Shorthead redhorse	202	38.4	7.6- 50.0	0.72	0.01- 1.62
Longnose sucker	67	35.6	17.8- 48.8	0.54	0.06- 1.24
White sucker	3	36.9	36.1- 37.8	0.58	0.54- 0.64
Mountain sucker	1	6.6	-	0.01	-
Channel catfish	1	50.3	-	1.10	-
Stonecat	2	12.3	8.9- 15.7	0.03	0.01- 0.05
Burbot	12	44.0	26.7- 71.1	0.53	0.11- 1.77
Sauger	358	34.3	13.2- 52.6	0.35	0.01- 1.36
Walleye	4	30.5	25.4- 40.1	0.26	0.12- 0.55
Freshwater drum	19	32.5	27.7- 42.9	0.46	0.26- 0.88
Total	1508				

Appendix Table 31. Species composition, number, and size of fish sampled by electrofishing in the Hole-in-the-Wall study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	56	81.7	69.3-97.0	2.52	1.54- 4.35
Goldeye	49	32.0	27.9-37.6	0.27	0.18- 0.38
Carp	2	47.6	44.4-50.8	1.32	1.01- 1.64
Flathead chub	11	19.9	11.4-29.0	0.11	0.02- 0.29
River carpsucker	2	44.8	43.9-45.7	1.25	1.10- 1.41
Blue sucker	36	72.1	63.5-79.5	3.50	2.04- 4.63
Smallmouth buffalo	9	59.0	47.2-65.5	3.24	1.63- 4.58
Bigmouth buffalo	5	72.0	66.8-81.3	6.70	4.94-12.25
Shorthead redhorse	12	42.4	28.7-49.5	0.94	0.66- 1.43
Longnose sucker	3	37.3	35.1-39.4	0.53	0.45- 0.59
Burbot	3	39.0	33.5-42.7	0.37	0.20- 0.49
Sauger	23	36.6	20.3-49.8	0.50	0.08- 1.05
Freshwater drum	1	30.5	-	0.37	-
Total	212				

Appendix Table 32. Species composition, number, and size of fish sampled by electrofishing in the Judith Landing study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	60	81.2	66.3-195.0	2.43	0.95-4.31
Goldeye	128	30.9	23.4- 34.5	0.28	0.14-0.45
Rainbow trout	1	42.7	-	0.67	-
Northern pike	1	88.6	-	5.31	-
Carp	29	47.3	40.4- 55.6	1.48	0.89-2.63
Flathead chub	41	16.2	8.9- 26.7	0.06	0.01-0.22
Emerald shiner	1	8.4	-	0.01	-
W. silvery minnow	12	11.4	8.9- 12.4	0.01	0.01-0.02
River carpsucker	28	43.4	18.5- 51.3	1.20	0.13-1.86
Blue sucker	52	68.9	61.5- 82.8	3.53	1.95-5.49
Smallmouth buffalo	15	59.6	49.8- 67.8	3.49	1.88-5.99
Bigmouth buffalo	11	72.6	66.3- 83.1	6.06	4.26-9.71
Shorthead redhorse	152	36.2	17.0- 51.8	0.59	0.07-1.51
Longnose sucker	40	32.8	11.2- 46.0	0.48	0.02-1.10
White sucker	6	26.9	16.5- 37.3	0.30	0.03-0.75
Channel catfish	10	59.9	47.2- 69.3	2.63	1.08-4.72
Stonecat	2	16.5	-	0.05	0.04-0.05
Burbot	12	41.0	24.6- 53.3	0.40	0.08-0.75
White crappie	2	19.3	17.8- 20.8	0.10	0.07-0.14
Sauger	189	30.2	11.7- 54.4	0.27	0.01-1.40
Walleye	1	42.9	-	0.76	-
Freshwater drum	9	31.6	27.9- 36.3	0.40	0.31-0.55
Mottled sculpin	1	5.8	-	0.01	-
Total	803				

Appendix Table 33. Species composition, number, and size of fish sampled by electrofishing in the Stafford Ferry study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	27	80.9	68.8-97.8	2.29	0.99-3.36
Goldeye	51	31.0	27.2-34.8	0.26	0.18-0.38
Carp	18	49.8	45.2-56.1	1.70	1.23-2.50
Flathead chub	9	19.0	12.2-24.4	0.08	0.02-0.15
River carpsucker	5	45.0	40.6-49.8	1.28	0.81-1.64
Blue sucker	59	71.3	63.0-83.3	3.49	1.63-5.35
Smallmouth buffalo	3	59.0	55.9-62.5	3.08	2.59-3.67
Bigmouth buffalo	5	78.5	68.6-82.6	9.09	5.81-11.20
Shorthead redhorse	32	40.8	17.3-50.3	0.74	0.05-1.37
Longnose sucker	6	36.3	22.4-44.4	0.57	0.14-0.82
Burbot	2	37.6	31.7-43.4	0.27	0.22-0.32
Sauger	23	37.7	29.2-52.1	0.46	0.10-1.35
Total	240				

Appendix Table 34. Species composition, number, and size of fish sampled by electrofishing in the Cow Island study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Pallid sturgeon	one observed, not captured				
Shovelnose sturgeon	78	76.2	59.7-96.5	1.92	0.51-4.58
Goldeye	148	30.6	14.0-35.1	0.29	0.04-0.45
Mountain whitefish	1	15.5	-	0.04	-
Carp	81	47.8	38.4-62.7	1.42	0.77-3.81
Flathead chub	22	16.0	9.9-20.8	0.05	0.01-0.12
W. silvery minnow	1	11.2	-	0.01	-
River carpsucker	15	43.1	36.1-47.2	1.08	0.64-1.61
Blue sucker	55	73.4	61.0-83.3	3.72	1.81-5.72
Smallmouth buffalo	21	56.9	49.0-67.3	2.88	1.63-6.40
Bigmouth buffalo	2	76.7	75.9-77.5	9.64	7.26-12.02
Shorthead redhorse	44	36.3	20.8-48.0	0.58	0.10-1.13
Longnose sucker	1	36.8	-	0.53	-
Channel catfish	1	68.6	-	4.63	-
Burbot	2	24.1	21.6-26.7	0.23	0.15-0.32
Sauger	33	31.2	15.2-51.1	0.28	0.05-1.07
Freshwater drum	3	28.8	26.9-30.7	0.32	0.23-0.36
Total	508				

Appendix Table 35. Species composition, number, and size of fish sampled by electrofishing in the Robinson Bridge study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Pallid sturgeon	two observed, not captured				
Shovelnose sturgeon	62	74.4	62.2-92.5	1.73	0.70-3.76
Goldeye	326	29.2	11.2-36.8	0.25	0.02-0.50
Carp	44	46.7	32.3-58.9	1.29	0.37-2.59
Flathead chub	32	12.2	6.4-24.1	0.06	0.01-0.14
Emerald shiner	14	8.0	5.3- 9.7	0.01	-
W. silvery minnow	24	10.8	9.1-12.4	0.02	0.01-0.03
River carpsucker	40	40.0	22.1-48.8	0.99	0.16-1.85
Blue sucker	20	75.6	65.0-84.8	4.07	2.15-5.72
Smallmouth buffalo	2	56.6	52.1-61.2	2.73	2.06-3.40
Bigmouth buffalo	1	71.4	-	5.90	-
Shorthead redhorse	40	34.0	22.9-49.5	0.45	0.15-1.17
Longnose sucker	2	23.6	20.1-27.2	0.18	0.10-0.26
White sucker	1	21.6	-	0.10	-
Channel catfish	1	51.1	-	1.07	-
Burbot	3	60.8	40.1-78.2	1.37	0.32-2.54
White crappie	1	24.6	-	0.24	-
Sauger	86	29.8	13.0-50.0	0.25	0.01-1.06
Walleye	1	35.6	-	0.34	-
Freshwater drum	3	30.2	25.9-33.0	0.36	0.22-0.44
Total	703				

Appendix Table 36. Species composition, number, and size of fish sampled by electrofishing in the Turkey Joe study section, 1976 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	1	68.6	-	1.39	-
Goldeye	40	27.2	17.3-35.6	0.23	0.05-0.49
Northern pike	1	59.9	-	1.36	-
Carp	16	36.8	22.4-50.0	0.76	0.19-1.47
W. silvery minnow	1	10.7	-	0.01	-
River carpsucker	3	38.6	25.1-45.7	0.93	0.22-1.31
Burbot	4	52.4	48.3-56.6	0.83	0.49-1.04
Sauger	30	31.9	20.8-42.7	0.27	0.06-0.69
Total	96				

Appendix Table 37. Species composition, number, and size of fish sampled by experimental gill netting in the Carter Ferry study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Goldeye	1	33.5	-	0.36	-
Northern pike	2	71.9	70.1-73.7	2.52	2.20-2.85
Shorthead redhorse	2	45.7	45.5-46.0	1.14	1.12-1.15
Longnose sucker	3	42.2	41.9-42.4	0.89	0.83-0.96
White sucker	2	43.3	41.4-45.2	1.07	0.93-1.21
Sauger	9	34.2	31.5-37.8	0.33	0.24-0.43
Total	19				

Appendix Table 38. Species composition, number, and size of fish sampled by experimental gill netting in the Fort Benton study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	3	91.7	86.6-96.5	3.28	2.81-3.90
Goldeye	96	31.7	28.2-38.4	0.28	0.18-0.48
Brown trout	1	47.2	-	1.92	-
Carp	17	50.8	44.2-57.4	1.76	1.18-2.40
Flathead chub	5	15.7	8.4-19.8	0.06	0.01-0.11
River carpsucker	6	41.3	37.6-45.2	0.90	0.57-1.27
Blue sucker	5	68.4	65.5-70.1	2.72	2.27-3.08
Smallmouth buffalo	2	60.2	58.4-62.0	3.40	3.36-3.45
Bigmouth buffalo	4	61.2	47.0-72.1	4.16	1.81-6.26
Shorthead redhorse	24	41.5	28.4-49.5	0.86	0.27-1.68
Longnose sucker	42	32.9	19.3-46.5	0.47	0.08-1.31
White sucker	10	33.5	18.5-43.7	0.53	0.08-0.93
Mountain sucker	3	10.2	8.4-13.7	0.02	0.02-0.03
Stonecat	2	14.2	13.7-14.7	0.04	0.04-0.05
Burbot	2	48.3	38.1-58.4	0.71	0.47-0.94
Sauger	23	31.3	24.6-42.9	0.25	0.10-0.54
Walleye	1	62.0	-	2.81	-
Freshwater drum	13	31.2	26.4-36.6	0.44	0.25-0.73
Total	259				

Appendix Table 39. Species composition, number, and sizes of fish sampled by experimental gill netting in the Loma Ferry study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	47	78.6	58.9-89.9	2.06	0.83-3.04
Goldeye	331	30.7	19.3-35.8	0.27	0.05-0.44
Northern pike	1	56.6	-	1.24	-
Carp	7	42.9	38.9-57.2	1.24	0.78-3.33
Flathead chub	3	18.7	16.5-20.6	0.07	0.05-0.09
River carpsucker	19	39.1	31.2-45.2	0.83	0.48-1.31
Smallmouth buffalo	2	57.8	53.8-61.7	2.65	2.36-3.04
Shorthead redhorse	42	42.2	20.8-50.3	0.97	0.41-1.58
Longnose sucker	23	40.9	22.6-49.5	0.87	0.13-1.32
Black bullhead	2	19.9	19.1-20.8	0.07	0.06-0.09
Stonecat	1	20.1	-	0.10	-
Burbot	1	73.2	-	2.05	-
Yellow perch	1	20.1	-	0.11	-
Sauger	17	30.2	18.0-41.1	0.23	0.05-0.67
Walleye	1	64.5	-	2.90	-
Freshwater drum	2	33.0	30.5-35.6	0.45	0.35-0.54
Total	500				

Appendix Table 40. Species composition, number, and size of fish sampled by experimental gill netting in the Coal Banks Landing study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	5	76.4	65.0-77.5	1.75	1.18-2.45
Goldeye	88	30.8	21.3-34.5	0.28	0.10-0.40
Carp	1	40.9	-	0.94	-
River carpsucker	1	40.1	-	0.77	-
Shorthead redhorse	20	38.1	25.1-48.3	0.65	0.19-1.29
Longnose sucker	6	38.2	26.9-41.9	0.67	0.21-0.85
White sucker	5	35.6	32.3-42.2	0.57	0.40-0.85
Channel catfish	2	73.7	-	5.24	4.94-5.53
Stonecat	1	16.5	-	0.05	-
White crappie	1	15.5	-	0.06	-
Yellow perch	1	19.6	-	0.13	-
Sauger	65	31.2	22.6-49.8	0.28	0.08-1.36
Walleye	2	31.7	27.4-36.1	0.33	0.18-0.47
Total	198				

Appendix Table 41. Species composition, number, and size of fish sampled by experimental gill netting in the Hole-in-the-Wall study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Goldeye	15	31.7	30.7-34.3	0.31	0.26-0.38
River carpsucker	1	41.1	-	1.04	-
Shorthead redhorse	4	43.6	40.6-49.5	1.11	0.82-1.43
Burbot	1	29.7	-	0.18	-
Sauger	4	34.7	28.7-45.0	0.38	0.16-0.83
Walleye	1	65.3	-	3.02	-
Total	26				

Appendix Table 42. Species composition, number, and size of fish sampled by experimental gill netting in the Judith Landing study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shovelnose sturgeon	2	74.7	73.2-76.2	1.79	1.72-1.86
Goldeye	26	29.2	25.9-32.5	0.23	0.16-0.32
Carp	5	47.2	41.4-51.6	1.39	0.92-1.91
Flathead chub	2	16.8	15.7-17.8	0.05	0.04-0.06
Shorthead redhorse	5	36.4	16.5-47.2	0.76	0.05-1.26
Longnose sucker	11	29.4	21.8-32.0	0.28	0.10-0.36
White sucker	1	26.2	-	0.19	-
Channel catfish	1	67.3	-	4.04	-
Burbot	1	37.6	-	0.28	-
Yellow perch	1	17.8	-	0.09	-
White crappie	4	18.7	18.0-19.1	0.09	0.08-0.11
Sauger	25	29.3	19.8-42.2	0.20	0.06-0.59
Total	84				

Appendix Table 43. Species composition, number, and size of fish sampled by experimental gill netting in the Stafford Ferry study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Shorthead redhorse	2	33.9	16.5-51.3	0.84	0.05-1.63
Stonecat	1	7.6	-	0.01	-
Sauger	2	37.8	34.5-41.1	0.46	0.32-0.60
Total	5				

Appendix Table 44. Species composition, number, and size of fish sampled by experimental gill netting in the Cow Island study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Goldeye	7	31.8	31.0-34.0	0.31	0.24-0.34
Sauger	15	35.9	27.9-47.2	0.38	0.16-0.83
Total	22				

Appendix Table 45. Species composition, number, and size of fish sampled by experimental gill netting in the Robinson Bridge study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Goldeye	294	28.6	16.5-36.8	0.23	0.03-0.40
Rainbow trout	1	47.2	-	1.30	-
Northern pike	3	65.6	65.3-66.0	1.82	1.63-2.04
Flathead chub	2	21.7	19.6-23.9	0.11	0.08-0.14
River carpsucker	27	38.2	22.1-46.5	0.91	0.16-1.61
Shorthead redhorse	1	27.7	-	0.26	-
White sucker	1	34.0	-	0.40	-
Channel catfish	1	67.3	-	4.10	-
White crappie	1	18.3	-	0.10	-
Yellow perch	1	19.3	-	0.09	-
Sauger	80	32.6	20.6-43.7	0.29	0.07-0.71
Walleye	3	39.4	34.8-46.0	0.63	0.39-0.71
Total	415				

Appendix Table 46. Species composition, number, and size of fish sampled by experimental gill netting in the Turkey Joe study section, 1976 and 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Goldeye	275	30.8	19.3-35.1	0.28	0.10-0.44
Northern pike	1	80.8	-	3.13	-
Carp	10	41.1	28.4-50.3	0.97	0.39-1.48
River carpsucker	40	42.7	24.4-46.2	1.08	0.20-1.60
Smallmouth buffalo	1	61.7	-	3.90	-
Shorthead redhorse	10	39.8	23.9-46.2	0.64	0.15-0.97
Channel catfish	3	39.5	31.0-43.9	0.60	0.27-0.78
White crappie	6	23.8	19.6-28.7	0.26	0.14-0.42
Sauger	181	35.5	22.1-54.6	0.37	0.09-1.17
Freshwater drum	4	28.6	25.7-32.7	0.30	0.22-0.45
Total	531				

Appendix Table 47. Species composition, number, and size of fish sampled with baited hoop nets at the Turkey Joe study site, 1977 through 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Channel catfish	1958	38.5	17.5-91.2	0.63	0.05-10.52
Sauger	15	41.8	34.3-51.8	0.57	0.31- 1.15
Burbot	2	47.0	44.2-49.8	0.54	0.43- 0.66
Freshwater drum	8	35.6	24.9-46.7	0.89	0.12- 1.86
Goldeye	2	29.5	28.4-30.2	0.25	0.21- 0.29
Shorthead redhorse	9	40.1	39.6-40.9	0.66	0.64- 0.67
Smallmouth buffalo	4	57.0	54.1-59.7	2.64	2.40- 2.90
River carpsucker	1	44.2	-	1.15	-
Carp	5	41.4	41.1-41.7	0.99	0.96- 1.02
Total	2004				

Appendix Table 48. Species composition, number, and size of fish sampled with baited hoop nets at the Two Calf Island study site, 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Channel catfish	6	56.2	38.1-77.0	2.53	0.40-6.30
Total	6				

Appendix Table 49. Species composition, number, and size of fish sampled with baited hoop nets at the Judith Landing study site, 1977.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Channel catfish	30	51.4	30.0-82.3	2.13	0.28-7.17
Shovelnose sturgeon	1	81.8	-	2.31	-
Sauger	3	47.8	35.6-53.4	1.07	0.43-1.56
Goldeye	1	30.5	-	0.27	-
Shorthead redhorse	1	35.6	-	0.58	-
Total	36				

Appendix Table 50. Species composition, number, and size of fish sampled with baited hoop nets at the Loma Ferry study site, 1978.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Channel catfish	8	56.7	41.9-74.2	2.22	0.58-4.76
Sauger	3	39.8	36.8-43.9	0.46	0.36-0.55
Shorthead redhorse	5	not measured			
Longnose sucker	4	not measured			
Carp	1	not measured			
Total	21				

Appendix Table 51. Species composition, number, and size of fish sampled with baited hoop nets in the lower Marias River study section, 1978 and 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Channel catfish	28	42.2	29.2-78.7	1.39	0.22-6.71
Shovelnose sturgeon	14	79.8	71.4-91.4	1.94	1.27-2.90
Sauger	6	41.1	37.6-47.2	0.54	0.41-0.87
Northern pike	1	52.8	-	1.12	-
Burbot	2	44.6	40.9-48.3	0.44	0.36-0.52
Goldeye	2	not measured			
White sucker	7	not measured			
Shorthead redhorse	5	not measured			
Longnose sucker	2	not measured			
River carpsucker	4	not measured			
Total	71				

Appendix Table 52. Species composition, number, and size of fish sampled with baited hoop nets in the lower Teton River study section, 1978 and 1979.

Fish Species	Number Sampled	Average Length (cm)	Length Range (cm)	Average Weight (kg)	Weight Range (kg)
Channel catfish	19	53.7	31.5-80.3	2.65	0.27-6.94
Sauger	6	41.5	37.3-51.6	0.54	0.39-0.91
River carpsucker	5	not measured			
Flathead chub	2	not measured			
Goldeye	1	not measured			
Shorthead redhorse	1	not measured			
Total	34				

Appendix Table 53. Numbers of fish sampled by electrofishing a 4-km study section of the lower Marias River during the spring/summer spawning migration periods from 1976 through 1979.

Date, 1976	5/5	5/10	5/14	5/19	5/27	6/4	6/9	6/17	6/28
Shovelnose sturgeon	0	1	5	16	45	26	24	18	8
Sauger	14	15	13	7	8	7	1	5	3
Blue sucker	1	0	0	0	1	0	0	3	1
Smallmouth buffalo	1	0	0	0	1	0	0	3	1
Bigmouth buffalo	0	0	0	0	0	0	1	0	0
River carpsucker	common from 5/19 - 6/9, abundant from 6/9 - 6/28								
Shorthead red-horse	abundant from 5/5 - 6/9, common from 6/9 - 6/28								
Longnose sucker	abundant from 5/5 - 6/9, common from 6/9 - 6/28								
Goldeye	common during the entire sampling period								

Date, 1977	4/27	5/10	5/24	6/7	6/21	7/6
Shovelnose sturgeon	0	0	4	7	7	0
Sauger	1	28	14	6	2	7
Blue sucker	2	0	0	0	0	0
Smallmouth buffalo	0	0	0	0	0	0
Bigmouth buffalo	0	0	0	0	0	0
River carpsucker	common from 5/10 - 5/24, abundant from 5/24 - 7/6					
Shorthead red-horse	abundant from 4/27 - 5/24, common from 5/24 - 6/21					
Longnose sucker	abundant from 4/27 - 5/24, common from 5/24 - 6/7					
Goldeye	common during the entire sampling period					

Date, 1978	5/1	5/9	5/16	6/2	6/9	6/20	6/23	6/27	7/3	7/10	7/18	8/4
Shovelnose sturgeon	0	0	0	0	4	6	19	18	15	5	21	13
Sauger	5	0	0	1	2	3	4	9	2	1	6	8
Blue sucker	3	0	3	0	0	2	4	0	3	0	2	5
Smallmouth buffalo	2	1	3	0	1	2	5	0	2	0	2	1
Bigmouth buffalo	1	2	3	3	1	1	0	0	2	0	0	0
River carpsucker	common from 5/16 - 6/2, abundant from 6/2 - 7/10											
Shorthead red-horse	abundant from 5/9 - 6/9, common from 6/9 - 7/3											
Longnose sucker	abundant from 5/1 - 6/9, common from 6/9 - 6/27											
Goldeye	common during the entire sampling period											

Appendix Table 53 continued. Numbers of fish sampled by electrofishing a 4-km study section of the lower Marias River during the spring/summer spawning migration period from 1976 through 1979.

Date, 1979	5/12	5/19	5/23	5/29	6/7	6/11	6/17	6/21
Shovelnose sturgeon	9	11	12	22	8	4	38	19
Sauger	38	58	8	50	39	7	33	3
Blue sucker	2	1	2	3	1	2	0	3
Smallmouth buffalo	1	0	1	0	2	0	0	6
Bigmouth buffalo	4	1	2	3	0	0	0	0
River carpsucker	common from 5/19 - 6/7, abundant from 6/7 - 6/21							
Shorthead redhorse	abundant from 5/12 - 6/7, common from 6/7 - 6/21							
Longnose sucker	abundant from 5/12 - 6/7, common from 6/7 - 6/21							
Goldeye	common during the entire sampling period							

Appendix Table 54. Numbers of sauger sampled by frame trapping in the lower Marias River during the spring/summer spawning migration periods from 1976 through 1978, with catch per unit effort statistics.

Date, 1976	5/11	5/12	5/13	5/15	5/18	5/20	5/21	1976 Total				
No. Days x No. Traps	1x1	1x1	1x1	2x2	3x2	2x2	1x2	-				
Trap-days	1	1	1	4	6	4	2	19 Trap-days				
No. Fish	3	2	1	2	3	5	3	19 Fish				
Fish/Trap-day	3.0	2.0	1.0	0.5	0.5	1.3	1.5	1.00 Fish/Trap-day				
Date, 1977	**3/9**	**3/10**	**3/11**	**3/13**	**3/14**	**3/16**	**3/18**	**3/20**	**3/22**	**3/25**	**3/28**	**3/31**
No. Days x No. Traps	1x1	1x3	1x3	2x3	1x3	2x4	2x4	2x4	2x4	3x4	3x4	3x4
Trap-days	1	3	3	6	3	8	8	8	8	12	12	12
No. Fish	1	3	2	17	0	3	1	2	0	8	1	1
Fish/Trap-day	1.0	1.0	0.7	2.8	0.0	0.4	0.1	0.3	0.0	0.7	0.1	0.1
1977, continued	**4/4**	**4/9**	**4/12**	**4/15**	**4/18**	**4/25**	**4/27**	**4/29**	**5/09**	**5/12**	**5/20**	**5/24**
No. Days x No. Traps	4x4	5x4	3x4	3x4	3x4	7x4	2x4	2x4	10x4	3x4	8x4	4x4
Trap-days	16	20	12	12	12	28	8	8	40	12	32	16
No. Fish	7	17	28	17	23	8	6	1	1	3	11	12
Fish/Trap-day	0.4	0.9	2.3	1.4	1.9	0.3	0.8	0.1	<0.1	0.3	0.3	0.8
1977, continued	**5/27**	**5/31**	**6/05**	**6/08**	**6/10**	**1977 Total**						
No. Days x No. Traps	3x4	4x4	5x4	3x4	2x4	-						
Trap-days	12	16	20	12	8	368 Trap-days						
No. Fish	2	1	1	0	1	178 Fish						
Fish/Trap-day	0.2	0.1	0.1	0.0	0.1	0.48 Fish/Trap-day						
1978	100 Trap-days, April 14 through May 9, produced two sauger for an average catch rate of 0.02 Fish/Trap-day.											

Appendix Table 55. Numbers of fish sampled with baited hoop nets in the lower Marias River during three time periods in 1978 and 1979, with catch per unit effort statistics

Species	August 3-9, 1978		Sept. 23-29, 1978		June 8-12, 1979	
	No. Fish	Fish/Net-day	No. Fish	Fish/Net-day	No. Fish	Fish/Net-day
Channel catfish	19	1.06	0	0.00	9	2.25
Shovelnose sturgeon	14	0.78	0	0.00	0	0.00
Sauger	4	0.22	1	0.08	1	0.25
Northern pike	1	0.06	0	0.00	0	0.00
Burbot	0	0.00	2	0.17	0	0.00
Goldeye	2	0.11	0	0.00	0	0.00
White sucker	0	0.00	7	0.58	0	0.00
Shorthead redhorse	0	0.00	5	0.42	0	0.00
Longnose sucker	0	0.00	2	0.17	0	0.00
River carpsucker	0	0.00	0	0.00	4	1.00

Appendix Table 56. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location		Date	Habitat	No. Fish	Species
CI 68	Cow Island	8- 3-76	Main Channel Border	17	W. silvery minnow
				13	Flathead chub
				4	Emerald shiner
				1	YOY sauger
CB 205	Near Little Sandy Cr.	8-23-76	Main Channel Border	2	YOY mt. whitefish
				1	Longnose dace
				1	Flathead chub
				1	YOY sh. redhorse
CI 70	Cow Island	8- 3-76	Side Channel Pool	4	YOY longnose sucker
				46	W. silvery minnow
				48	Flathead chub
CB 205	Near Little Sandy Cr.	8-24-76	Backwater	2	White crappie (<12mm TL)
				4	Emerald shiner
CB 204	Near Little Sandy Cr.	8-24-76	Main Channel Riffle	1	Stonecat
				1	Flathead chub
				1	YOY longnose sucker
				2	YOY sh. redhorse
FB 285	Near Fort Benton	9-20-76	Main Channel Border	22	Flathead chub
				4	YOY longnose sucker
JL 137	Near Judith Landing	3-20-77	Main Channel Riffle	5	Longnose dace
CB 210	Near Coal Banks Landing	10-11-76	Main Channel Border	21	Emerald shiner
				14	W. silvery minnow
				8	YOY r. carpsucker
				3	YOY longnose sucker
				5	YOY sh. redhorse

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location		Date	Habitat	No. Fish	Species
CB 211	Near Coal Banks Landing	10-12-76	Main Channel Border	40	Flathead chub
				4	Emerald shiner
				13	YOY r. carpsucker
				4	YOY w. sucker
				17	W. silvery minnow
JL 138	Near Judith Landing	9-27-76	Backwater	68	Emerald shiner
				41	Flathead chub
				16	YOY goldeye
				2	YOY carp
TJ 2	Turkey Joe	4-20-77	Backwater	41	Emerald shiner
				3	W. silvery minnow
				15	YOY r. carpsucker
LF 246	Near Loma Ferry	6- 7-77	Side Channel Pool	12	Emerald shiner
				20	Flathead chub
				5	Longnose dace
				3	YOY sh. redhorse
MR 3	Marias River near mouth	6- 7-77	Main Channel Riffle	7	Longnose dace
MR 3	Marias River near mouth	6- 7-77	Main Channel Pool	17	Emerald shiner
				2	Flathead chub
				4	YOY sh. redhorse
MR 2	Marias River near mouth	6- 7-77	Main Channel Pool	11	Emerald shiners
				23	YOY sh. redhorse
				2	Flathead chub
MR 2	Marias River near mouth	6- 7-77	Main Channel Riffle	14	Longnose dace
				6	YOY sh. redhorse

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
MR 2 Marias River near mouth	6- 7-77	Main Channel Pool	18	YOY sh. redhorse
			14	Flathead chub
			9	Longnose dace
MR 1 Marias River near mouth	6- 7-77	Main Channel Pool	53	Longnose dace
			18	Emerald shiner
			13	YOY white sucker
			3	Flathead chub
			2	W. silvery minnow
			1	YOY longnose sucker
MR 1 Marias River near mouth	6- 7-77	Main Channel Pool	8	YOY sh. redhorse
			5	Emerald shiner
			2	Flathead chub
LF 253 Near Loma Ferry	6- 8-77	Side Channel Pool	8	Emerald shiner
			6	YOY sh. redhorse
			4	Longnose dace
			3	Flathead chub
			2	Fathead minnow
HW 155 Near Arrow Creek	6-16-77	Main Channel Border	3	Stonecats
			8	Emerald shiner
			2	Longnose dace
			2	YOY sh. redhorse
SF 111 Below Dauphine Rapids	6-17-77	Main Channel Border	56	Emerald shiner
			6	YOY sh. redhorse
			3	Flathead chub
			1	YOY white sucker

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
CI 65 Below Cow Island	6-17-77	Main Channel Border	80	Emerald shiner
			52	W. silver minnow
			25	Flathead chub
			10	YOY sh. redhorse
			6	Plains minnow
			1	YOY sauger
HW 177 Near Hole-in-the-Wall	6-30-77	Main Channel Border	80	YOY sh. redhorse
			5	Emerald shiner
			5	Flathead chub
LF 246 Near Loma Ferry	7-15-77	Side Channel Pool	600	YOY longnose sucker
			100	YOY carp
			10	Flathead chub
			10	Longnose dace
MR 1 Marias River near mouth	7-15-77	Main Channel Pool	63	YOY longnose sucker
			18	W. silvery minnow
			17	Emerald shiner
			3	Fathead minnow
			1	YOY mt. whitefish
MR 1 Marias River near mouth	7-15-77	Main Channel Border	300	YOY longnose sucker
			11	YOY carp
			2	Longnose dace
JL 138 Near Judith Landing	7-27-77	Backwater	31	Emerald shiner
			10	Flathead chub
			2	YOY longnose sucker

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
JL 138 Near Judith Landing	7-27-77	Main Channel Border	75	YOY longnose sucker
			75	YOY sh. redhorse
			16	Flathead chub
			10	Longnose dace
			4	Emerald shiner
JL 138 Near Judith Landing	7-27-77	Side Channel Run	15	Emerald shiner
			14	Flathead chub
			5	YOY goldeye
			4	YOY longnose sucker
			3	Longnose dace
			3	YOY sh. redhorse
			1	YOY r. carpsucker
			1	YOY carp
JL 132 Below Judith Landing	7-28-77	Side Channel Pool	60	Flathead chub
			75	Emerald shiner
			20	YOY longnose sucker
			30	YOY sh. redhorse
			3	YOY carp
			10	Longnose dace
JL 132 Below Judith Landing	7-28-77	Side Channel Pool	125	YOY longnose sucker
			175	Flathead chub
JL 132 Below Judith Landing	7-28-77	Main Channel Border	40	Flathead chub
			20	Emerald shiner
			5	YOY sh. redhorse
			2	YOY carp
SF 104 Near Lone Pine Rapids	8- 2-77	Side Channel Riffle	3	Flathead chub
			1	YOY longnose sucker

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
SF 104 Near Lone Pine Rapids	8- 2-77	Side Channel Pool	45	Flathead chub
			25	YOY sh. redhorse
			5	YOY longnose sucker
			5	W. silvery minnow
SF 104 Near Lone Pine Rapids	8- 2-77	Main Channel Border	50	Flathead chub
			15	YOY sh. redhorse
			15	W. silvery minnow
			10	YOY longnose sucker
SF 104 Near Lone Pine Rapids	8- 2-77	Main Channel Border	20	W. silvery minnow
			20	Flathead chub
			15	YOY sh. redhorse
			20	Emerald shiner
			5	YOY goldeye
LF 249 Above Loma Ferry	8- 6-78	Main Channel Riffle	44	Emerald shiner
			40	Longnose dace
			14	Flathead chub
			8	YOY longnose sucker
LF 249 Above Loma Ferry	8- 6-78	Main Channel Border	47	Longnose dace
			12	YOY longnose sucker
			9	Flathead chub
			1	YOY sh. redhorse
			1	YOY w. sucker
LF 250 Above Loma Ferry	8- 6-78	Side Channel Pool	30	YOY longnose sucker
			45	Longnose dace
			1	Fathead minnow
			30	YOY sh. redhorse
			3	Flathead chub
			1	Emerald shiner

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
LF 250 Above Loma Ferry	8- 6-78	Main Channel Riffle	17	Longnose dace
			1	YOY longnose sucker
LF 250 Above Loma Ferry	8- 6-78	Main Channel Border	41	YOY longnose sucker
			22	Longnose dace
			4	YOY sh. redhorse
			12	Emerald shiner
LF 249 Above Loma Ferry	8- 6-78	Backwater	51	YOY sh. redhorse
			30	Longnose dace
			20	YOY longnose sucker
			2	Flathead chub
			1	Emerald shiner
LF 249 Above Loma Ferry	8- 6-78	Backwater	60	Longnose dace
			40	YOY longnose sucker
			4	Flathead chub
			2	Emerald shiner
			1	YOY white sucker
LF 249 Above Loma Ferry	8- 6-78	Backwater	40	YOY longnose sucker
			15	Longnose dace
			12	Fathead minnow
			10	Flathead chub
			5	Emerald shiner
			4	YOY sh. redhorse
LF 249 Above Loma Ferry	8- 6-78	Side Channel Riffle	46	Flathead chub
			10	Longnose dace
			10	YOY longnose sucker
			1	Fathead minnow

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location		Date	Habitat	No. Fish	Species
LF 248	Above Loma Ferry	8- 6-78	Side Channel Pool	25	Flathead chub
				30	Longnose dace
				10	YOY longnose sucker
				8	Fathead minnow
				3	YOY sh. redhorse
				1	Emerald shiner
LF 248	Above Loma Ferry	8- 6-78	Main Channel Riffle	10	Longnose dace
				10	YOY longnose sucker
				3	Emerald shiner
				2	Flathead chub
LF 249	Above Loma Ferry	8- 6-78	Main Channel Riffle	40	Longnose dace
				30	YOY longnose sucker
				30	YOY sh. redhorse
				4	Flathead chub
				3	Emerald shiner
LF 250	Above Loma Ferry	8- 6-78	Main Channel Riffle	33	Flathead chub
				22	Longnose dace
				5	YOY longnose sucker
				1	Fathead minnow
				1	Emerald shiner
				1	YOY sh. redhorse
MR 1	Marias River near mouth	8- 6-78	Main Channel Pool	35	Flathead chub
				10	YOY longnose sucker
				6	W. silvery minnow
				3	Emerald shiner
				2	YOY sh. redhorse

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
MR 1 Marias River near mouth	8- 6-78	Main Channel Pool	74	Flathead chub
			20	Emerald shiner
			25	YOY longnose sucker
			10	YOY sh. redhorse
			6	W. silvery minnow
MR 4 Marias River near mouth	8- 6-78	Main Channel Riffle	8	Flathead chub
			12	Longnose dace
			5	YOY longnose sucker
			2	Emerald shiner
MR 4 Marias River near mouth	8- 6-78	Main Channel Riffle	60	Flathead chub
			25	YOY longnose sucker
			40	Longnose dace
			5	Emerald shiner
			1	YOY mt. whitefish
MR 5 Marias River near mouth	8- 7-78	Main Channel Pool	30	Flathead chub
			18	YOY longnose sucker
			30	Longnose dace
			6	Emerald shiner
			2	YOY sh. redhorse
MR 5 Marias River near mouth	8- 7-78	Main Channel Pool	40	Longnose dace
			20	YOY longnose sucker
			12	Flathead chub
			9	YOY sh. redhorse
			6	Emerald shiner
MR 4 Marias River near mouth	8- 7-78	Side Channel Pool	9	Longnose dace
			6	Flathead chub

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
MR 4 Marias River near mouth	8- 7-78	Side Channel Pool	75	Flathead chub
			70	YOY longnose sucker
			60	Longnose dace
			2	YOY sh. redhorse
			2	YOY mt. whitefish
			2	Emerald shiner
LF 236 Near Churchill Bend	8- 8-78	Backwater	12	Longnose dace
			15	Flathead chub
			5	Emerald shiner
			1	YOY longnose sucker
LF 236 Near Churchill Bend	8- 8-78	Backwater	25	Flathead chub
			25	YOY longnose sucker
			10	Longnose dace
			2	Fathead minnow
LF 237 Near Churchill Bend	8- 8-78	Backwater	75	Flathead chub
			30	YOY longnose sucker
			10	Longnose dace
			5	Fathead minnow
			5	YOY sm. buffalo
			2	Emerald shiner
LF 237 Near Churchill Bend	8- 8-78	Backwater	45	Flathead chub
			30	YOY longnose sucker
			10	Longnose dace
			5	Emerald shiner
			5	Fathead minnow
			2	YOY bm. buffalo

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
LF 237 Near Churchill Bend	8- 8-78	Side Channel Riffle	35	Flathead chub
			35	Longnose sucker
			25	Longnose dace
			5	Fathead minnow
LF 237 Near Churchill Bend	8- 8-78	Main Channel Riffle	11	Flathead chub
			10	Emerald shiner
			4	Longnose dace
			1	YOY longnose sucker
LF 243 Near Archers Island	8- 8-78	Main Channel Border	9	Emerald shiner
			8	Flathead chub
			6	Longnose dace
			4	YOY longnose sucker
			1	Fathead minnow
			6	W. silvery minnow
			1	YOY sh. redhorse
LF 243 Near Archers Island	8- 8-78	Main Channel Border	10	Emerald shiner
			10	Flathead chub
			2	Longnose dace
			1	YOY sh. redhorse
LF 243 Near Archers Island	8- 8-78	Main Channel Border	20	Flathead chub
			16	W. silvery minnow
			8	Emerald shiner
			2	Longnose dace
			1	YOY longnose sucker
LF 247 Near Loma Ferry	8- 8-78	Main Channel Border	25	Longnose dace
			20	Fathead minnow
			8	Emerald shiner

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
LF 247 Near Loma Ferry	8- 8-78	Main Channel Border	40	Longnose dace
			7	Flathead chub
			1	Emerald shiner
			1	YOY longnose sucker
LF 246 Near Loma Ferry	8- 8-78	Side Channel Pool	40	Fathead minnow
			4	YOY sh. redhorse
			1	Flathead chub
			1	Emerald shiner
CF 305 Near Carter Ferry	10-28-77	Backwater	3	Emerald shiner
			1	Mottled sculpin
CF 305 Near Carter Ferry	10-28-77	Main Channel Border	4	Longnose dace
			1	Mountain sucker
CF 305 Near Carter Ferry	10-28-77	Backwater	1	W. silvery minnow
			125	Emerald shiner
MD 320 Near Highwood Creek	10-28-77	Main Channel Riffle	20	Longnose dace
			14	Mountain sucker
MD 322 Near Highwood Creek	10-28-77	Backwater	10	Flathead chub
			8	YOY sh. redhorse
			4	Emerald shiner
			2	W. silvery minnow
FB 282 Near Fort Benton	11- 4-77	Main Channel Border	8	YOY sh. redhorse
FB 281 Near Fort Benton	11- 4-77	Main Channel Border	20	YOY sh. redhorse
			4	W. silvery minnow

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location		Date	Habitat	No. Fish	Species
LF 250	Near Loma Ferry	11- 4-77	Backwater	80	Fathead minnow
				12	YOY carp
				7	Emerald shiner
CB 205	Near Little Sandy Cr.	10-21-77	Main Channel Border	7	YOY r. carpsucker
				5	YOY sh. redhorse
				3	Emerald shiner
				2	W. silvery minnow
				1	YOY longnose sucker
CB 205	Near Little Sandy Cr.	10-21-77	Side Channel Pool	20	Emerald shiner
				7	YOY sh. redhorse
				1	YOY longnose sucker
HW 170	Near Steamboat Rock	10-23-77	Main Channel Border	3	YOY sh. redhorse
				1	YOY r. carpsucker
				1	Emerald shiner
HW 170	Near Steamboat Rock	10-23-77	Main Channel Border	11	Emerald shiner
				2	Flathead chub
				1	YOY sh. redhorse
SF 95	Above Bird Rapids	10-24-77	Main Channel Riffle	13	Emerald shiner
				2	Flathead chub
				1	W. silvery minnow
SF 95	Above Bird Rapids	10-24-77	Main Channel Border	7	Flathead chub
				6	Emerald shiner
				1	YOY longnose sucker

Appendix Table 56 continued. Summary of forage fish surveys conducted on the middle Missouri River from 1976 through 1979, showing location, date of collection, and habitat sampled. Each data entry represents one seine haul.

Location	Date	Habitat	No. Fish	Species
JL 134 Below Judith Landing	11- 8-77	Main Channel Border	30	Emerald shiner
			25	YOY longnose sucker
			20	Longnose dace
			10	W. silvery minnow
			10	YOY r. carpsucker
			6	YOY sh. redhorse
			5	Fathead minnow
			5	YOY white sucker
CI 70 Near Cow Island	10-25-77	Main Channel Border	6	Flathead chub
			1	YOY sauger
			1	YOY goldeye
			1	YOY sh. redhorse
FB 272 Near Evans Bend	7-24-79	Main Channel Border	39	Emerald shiner
			46	YOY carp
			7	Flathead chub
			30	YOY longnose sucker
			1	Longnose dace
			3	Fathead minnow
LF 258 Near Fort Brule	7-24-79	Main Channel Border	35	YOY longnose sucker
			19	Emerald shiner
			25	Flathead chub
			2	Longnose dace

MISSOURI RIVER FISHERMAN SURVEY

Seven of the most important or common game fish species found in the middle Missouri River in Montana are shown on this IDENTIFICATION CHART. These species are of particular interest to the Montana Department of Fish and Game, and the department is presently surveying fishermen to provide information about them. Please record your catch for each of these species on the appropriate line of the FISHERMAN SURVEY card.

Most fishermen will also catch some of the other common fish species in the river, such as goldeye, carp, river carpsuckers, longnose and white suckers, etc. If you catch any of these fish, please record the total number you caught on the "Other Kinds" line of the FISHERMAN SURVEY card.

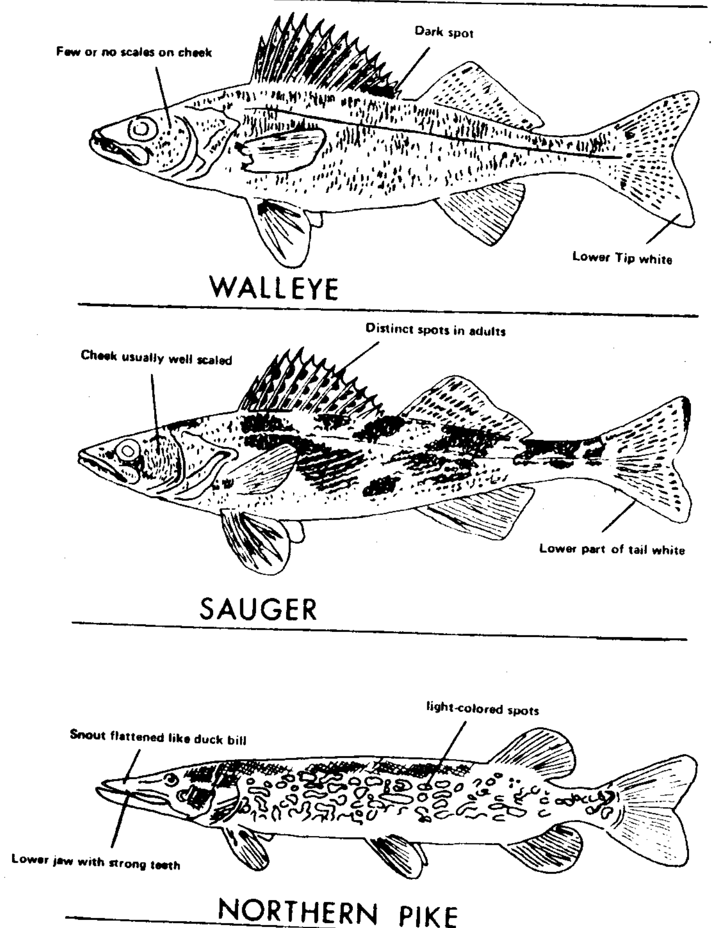
Please mail your completed FISHERMAN SURVEY card. It is postpaid. Your cooperation is appreciated.

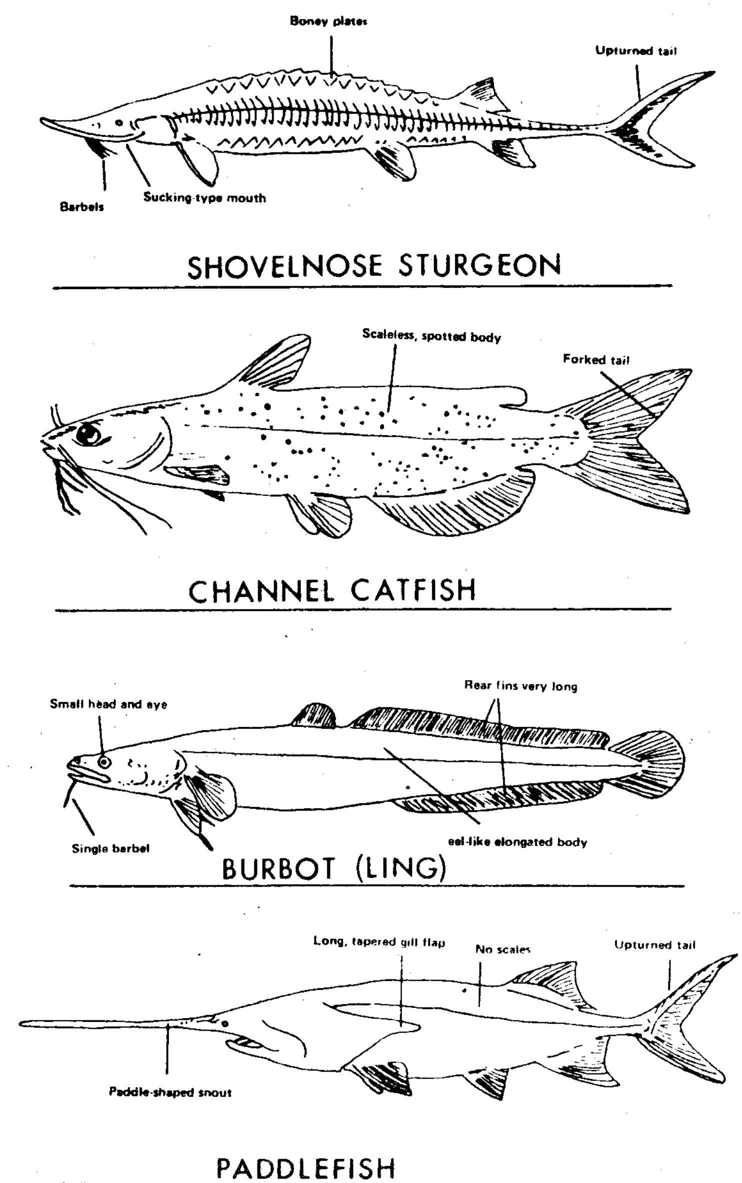
Thank you,

MONTANA DEPARTMENT OF FISH AND GAME

IDENTIFICATION CHART

IMPORTANT GAME FISH · MISSOURI RIVER – GREAT FALLS To FORT PECK LAKE





Appendix Figure 1. Fish species identification chart for Missouri River fisherman survey.

MONTANA DEPARTMENT OF FISH AND GAME
MISSOURI RIVER FISHERMAN SURVEY – ONE PARTY, ONE TRIP

Please answer the following questions as a combined total for all persons in your party who fished during your trip. Return the card even if you caught no fish.

Number of anglers in party ________ Angler's residence(s) ______________________________
Date(s) fished ________________ Section of river fished ______________________________
Total hours spent fishing ______________________ (combined total for party)
Fishing from: ( )Bank, ( )Boat, ( ) Combination
Method(s): ( ) Setline, ( ) Angling (hand-held line with lure), ( ) Snagging
Lure(s): ( ) Live bait, ( ) Prepared bait, ( ) Artificial lure, other (specify) ____________

Fish Species	CATCH Number Kept	Number Released
Sauger		
Walleye		
Sturgeon		
Catfish		
Northern Pike		
Burbot (ling)		
Paddlefish		
Other kinds		

Please mail your completed card. It is postpaid. Your contribution will help to provide a better fisheries resource for Montana sportsmen.

MONTANA DEPARTMENT OF FISH AND GAME
MISSOURI RIVER FISHERMAN SURVEY – ONE ANGLER, ONE TRIP

Angler's residence (city, state) ______________________ Interview No. ____________
Date(s) fished __________________________ Section of river fished ____________
Total hours spent fishing: __________ Fishing Trip: ( ) Complete, ( ) Not Complete
Fishing from: ( ) Bank, ( ) Boat, ( ) Combination
Method(s): ( ) Setline, ( ) Angling (hand-held line with lure), ( ) Snagging
Lure(s): ( ) Live bait, ( ) Prepared bait, ( ) Artificial lure, other (specify) __________

Fish Species	Catch When Interviewed		Additional Catch After Interview	
	Number Kept	Number Released	Number Kept	Number Released
Sauger				
Walleye				
Sturgeon				
Catfish				
Northern Pike				
Burbot (Ling)				
Paddlefish				
Other kinds				

If your fishing trip was not complete when you were contacted, please record any additional fish caught after the interview in the last columns (above). Answer for yourself only, do not include fish caught by others in your party. Additional number of hours spent fishing after interview ____________ . Additional date(s) fished after interview: ______________________ . Please mail your completed card. It is postpaid. Your contribution will help to provide a better fisheries resource for Montana sportsmen.

Appendix Figure 2. "Voluntary" (top) and "interview" (bottom) fisherman survey forms used in Missouri River fisherman survey.